



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2022

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 20 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 seven** 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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Section A

1 Identify the main inorganic ion involved in each of the following:

- pectate in the middle lamella of cell walls

Calcium (Ca^{2+})

- chlorophyll

Magnesium (Mg^{2+})

- haemoglobin

Iron (Fe^{2+})

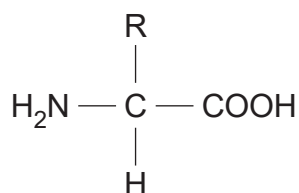
- buffering systems

Hydrogencarbonate (HCO_3^-)

[4]



- 2 The diagram below represents the general structure of an amino acid molecule. There are approximately 20 different amino acids.



- (a) Using the diagram, describe how amino acids differ.

Each amino acid has a different (variable) R group.

[1]

- (b) Proteins may be described as having primary, secondary and tertiary structures.

- (i) Describe what is meant by the 'primary structure' of a protein, and identify the type of bond involved.

The primary structure is the sequence (order) of amino acids in a polypeptide chain.

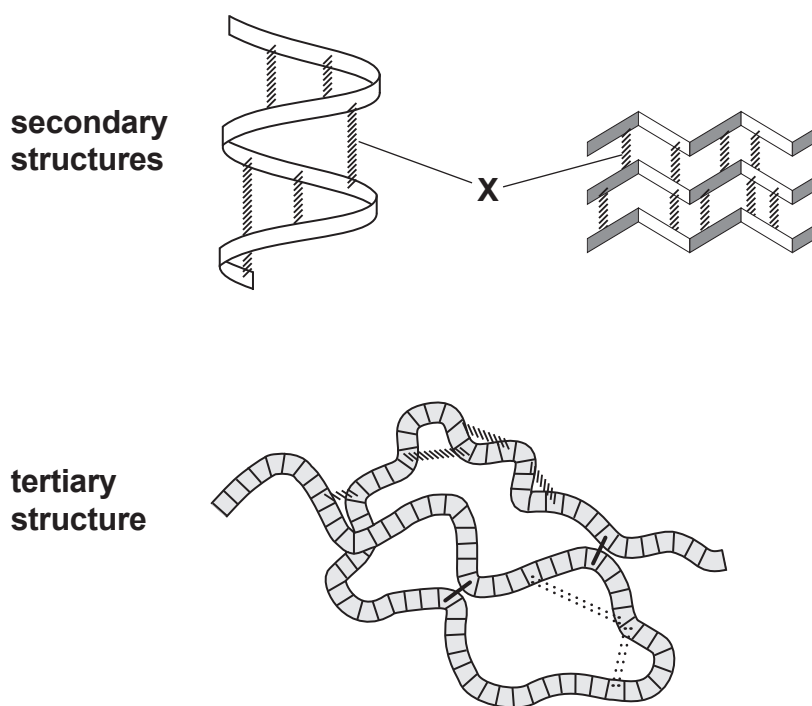
The amino acids are joined by peptide bonds.

[2]

[Turn over]



The diagram below represents the α -helix and β -pleated sheet secondary protein structures, together with the tertiary structure.



Note: Only some bonds are shown in the protein.

Source: © Biology for CCEA, AS Level by Dr James Napier (ISBN: 9781780730998) Published by Colourpoint Educational, 2016

(ii) Identify the bonds labelled **X** in the diagram.

Hydrogen bonds

[1]

(iii) Using the diagram and your knowledge, compare and contrast the bonds present in secondary and tertiary structures of proteins.

Both secondary and tertiary structures are held together by (peptide bonds and) hydrogen bonds.

However, tertiary structures also contain other bonds such as disulfide bridges and ionic bonds, and hydrophobic/hydrophilic interactions.

[2]



- (iv) Using the diagram and your knowledge, state the function of fibrous proteins and explain how their structure adapts them for this role.

Fibrous proteins have a structural role, providing support (strength).

This is due to many polypeptide chains wound around each other in a rope-like structure, linked by many cross links (hydrogen bonds), e.g. collagen.

[2]

- (c) Proteins such as amylase can become denatured due to changes in pH and this can have a significant effect on the ability of the protein to function.

Explain precisely how a change in pH can cause amylase to lose its ability to carry out its function.

A change in pH alters the charges on the R groups, so the ionic bonds (and hydrogen bonds) holding the tertiary structure are disrupted and break.

This causes the specific shape of the active site to be lost, so it is no longer complementary to starch and no enzyme-substrate complexes can form.

[2]

[Turn over]

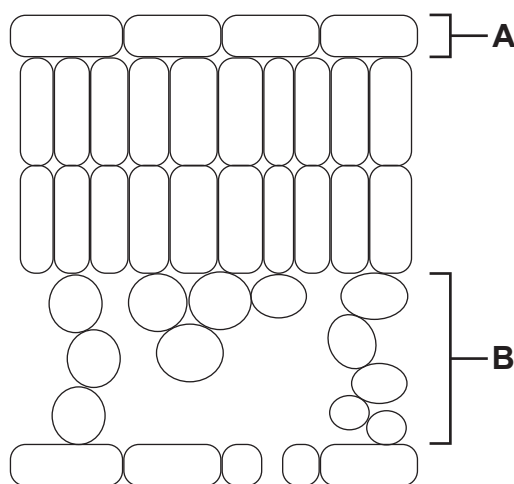


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3 (a) The drawing below represents a section through a mesophytic leaf.



Note: No cell detail is provided in the drawing.

Source: Chief Examiner

(i) Identify the tissue layers labelled **A** and **B**.

A Upper epidermis

B Spongy mesophyll

[2]

(ii) Using **only** features shown in the diagram, describe **two** ways in which the leaf represented is adapted to maximise light absorption.

1. There is a double layer of palisade mesophyll cells, so more
chloroplasts to absorb light.

2. The palisade cells are tightly packed and the epidermal cells are
thin and horizontally orientated, letting light through.

[2]

[Turn over]



(b) Chloroplasts contain the pigment chlorophyll, which absorbs light.

(i) Identify the part of the chloroplast where chlorophyll is located.

In the thylakoid membranes (grana)

[1]

Scientists investigated how the size and number of chloroplasts in leaf cells affected the photosynthesis rate.

They investigated two varieties of thale cress (*Arabidopsis thaliana*) – the ‘normal’ variety **A** and variety **B**, which had fewer but larger chloroplasts.

Some of the data collected is shown in the table below.

Plant variety	Mean number of chloroplasts per cell	Mean chloroplast area / μm^2	Mean chlorophyll content / gm^{-2}	Mean rate of photosynthesis / arbitrary units
A	100	14.6	0.239	7.69
B	2	198.2	0.233	3.86

(ii) Identify the dependent variable in this investigation.

The (mean) rate of photosynthesis.

[1]

Source:

Q3.....© Xiong, D., Huang, J., Peng, S. et al. A few enlarged chloroplasts are less efficient in photosynthesis than a large population of small chloroplasts in *Arabidopsis thaliana*. Sci Rep 7, 5782 (2017). <https://doi.org/10.1038/s41598-017-06460-0>
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(iii) Consider the hypothesis:

'A higher rate of photosynthesis occurs in plants which contain larger chloroplasts.'

Comment on whether the data in the table provides evidence to support this hypothesis.

The data does not support (contradicts) the hypothesis.

Variety A, which has smaller chloroplasts ($14.6 \mu\text{m}^2$), has a higher mean rate of photosynthesis (7.69 au) than variety B, which has larger chloroplasts ($198.2 \mu\text{m}^2$) and a rate of only 3.86 au.

[2]

(iv) It is thought that larger chloroplasts are less able to move around within palisade cells.

Using all the information provided, suggest an explanation for the outcome of the investigation.

Variety A has many smaller chloroplasts which can move (orientate) within the palisade cells to the position of greatest light intensity, so more light is absorbed, resulting in more (faster) photosynthesis. The larger chloroplasts in B cannot move as easily, so they absorb less light.

[2]

[Turn over]



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4 Enzymes are biological catalysts which speed up reactions. They may require a cofactor.

(a) Define the term 'cofactor'.

A non-protein component (substance) that an enzyme requires in order to function.

[1]

(b) In mammals, the function of the ileum is to digest and absorb nutrients. Amylase breaks down starch into maltose. Maltose is then broken down by maltase, an enzyme which is embedded in the membrane of the microvilli of cells lining the gut lumen.

(i) Name the **tissue layer** of the ileum where microvilli are found.

Mucosa (epithelium)

[1]

(ii) Distinguish precisely between microvilli and villi in the ileum.

*Microvilli are microscopic extensions of the cell surface membrane of a single epithelial cell,
whereas villi are larger, finger-like extensions of the ileum wall, each made up of many cells.*

[2]

(iii) Suggest **one** advantage of maltase being embedded in the membrane of the microvilli, rather than being released into the gut lumen.

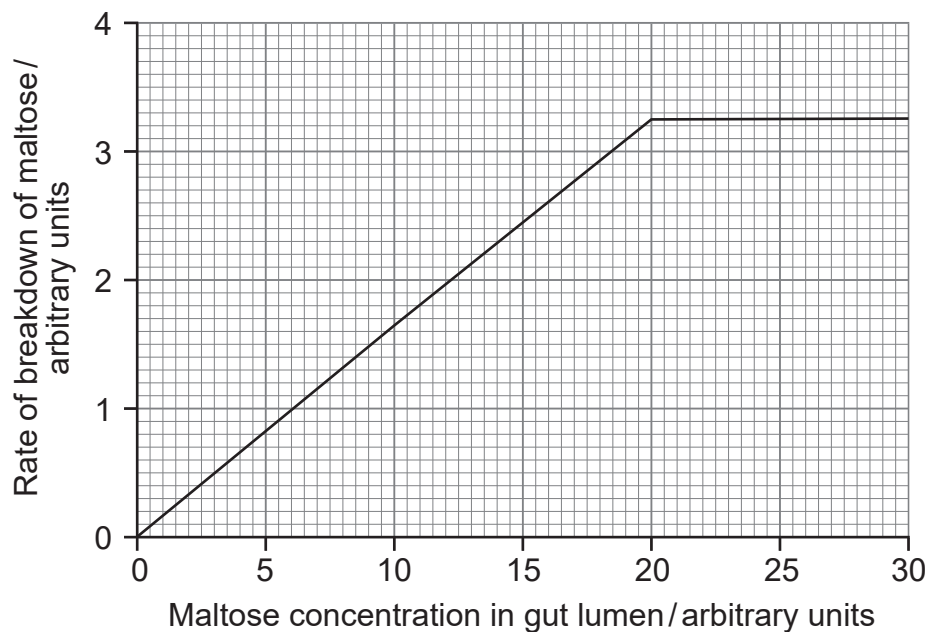
The enzyme is less likely to be lost (with the gut contents), so it does not need to be continually replaced.

[1]

[Turn over]



- (c) In an experiment, the relationship between the concentration of maltose in the lumen of the gut and the rate of breakdown of maltose by maltase was investigated. The results are shown in the graph below.



- (i) Calculate the percentage increase in the rate of breakdown of maltose when the maltose concentration increased from 10 to 20 arbitrary units. (Show your working.)

$$\text{Rate at 10 au} = 1.65 \text{ au} \quad \text{Rate at 20 au} = 3.25 \text{ au}$$

$$\text{Increase} = 3.25 - 1.65 = 1.6 \text{ au}$$

$$\% \text{ increase} = (1.6 \div 1.65) \times 100 = 96.97$$

97.0 % [3]



(ii) Describe and explain the results of the investigation.

As maltose concentration increases from 0 to 20 au, the rate of maltose breakdown increases (linearly) up to a maximum of 3.25 au, then levels off (stays constant) from 20 to 30 au.

Up to 20 au, as maltose concentration increases there are more substrate molecules available, so more of the enzymes (active sites) are utilised, forming more enzyme-substrate complexes and converting more maltose to glucose.

At the maximum, all the enzymes are utilised (all active sites are occupied), so the enzyme concentration is limiting.

[3]



5 DNA and RNA are nucleic acids.

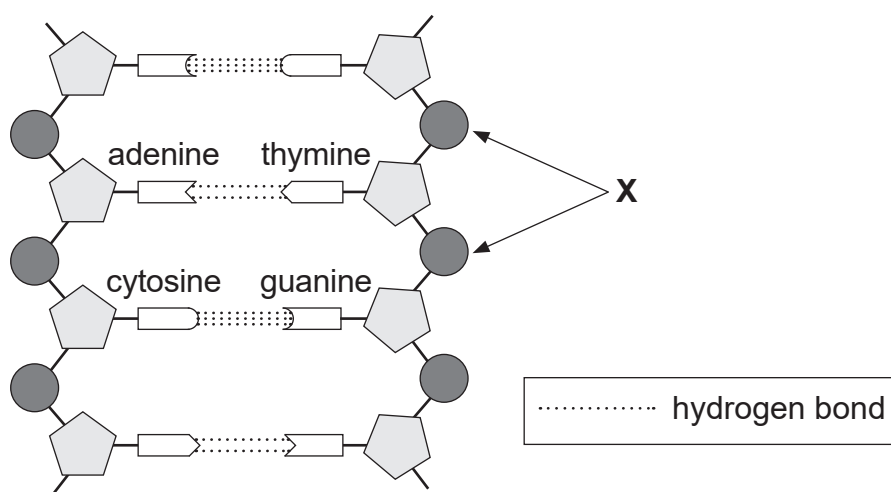
(a) Other than the number of strands, state **two** structural differences between DNA and RNA.

1. In RNA the base thymine is replaced by uracil.

2. RNA has the sugar ribose rather than deoxyribose (as in DNA).

[2]

The diagram below represents a short section of DNA.



Source: © Biology for CCEA, AS Level by Dr James Napier (ISBN: 9781780730998)
Published by Colourpoint Educational, 2016

(b) Identify the components labelled X.

X Phosphate (group)

[1]

(c) Before a cell divides to form two new cells, the DNA is replicated.

(i) Explain why it is necessary for the DNA to be replicated before a cell divides.

So that each daughter cell receives the full (normal) DNA complement.

[1]



The process by which DNA is copied is known as semi-conservative replication.

(ii) Describe the process of semi-conservative replication.

DNA helicase breaks the hydrogen bonds between the complementary bases, so the two strands separate, each acting as a template strand.

Free DNA nucleotides bind (by hydrogen bonds) to their complementary bases on each template strand: A with T and C with G.

DNA polymerase then joins the nucleotides of each new strand, so each new molecule has one original and one new strand.

[3]

(iii) The position on the DNA where replication begins is referred to as the 'origin of replication'.

The section of DNA that contains the origin of replication usually has a high proportion of adenine and thymine base pairs. Using the diagram opposite, suggest a possible explanation for this.

Adenine and thymine are joined by only two hydrogen bonds, whereas cytosine and guanine are joined by three.

So it is easier (less energy is required) to break the bonds and separate the strands where replication begins.

[2]

[Turn over]

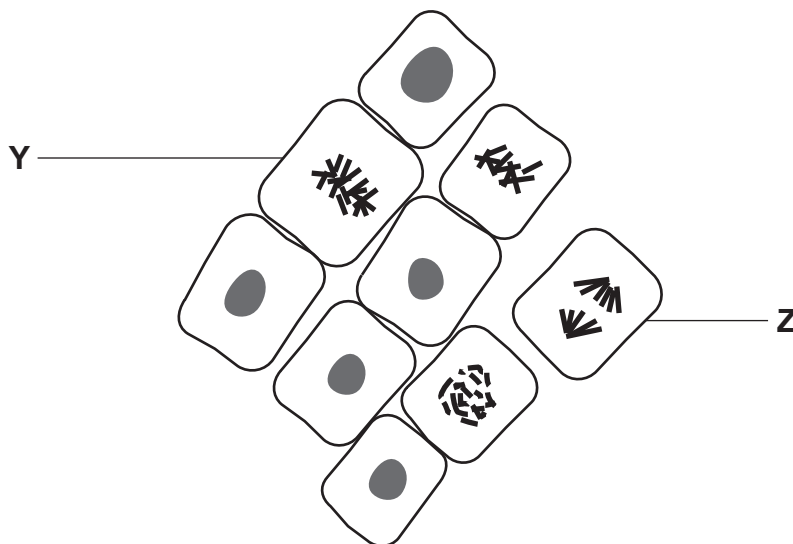


- (iv) State precisely the part of the cell cycle in which semi-conservative replication occurs.

The S phase (synthesis phase) of interphase

[1]

- (d) The drawing below represents some cells from a section through an onion root tip.



Source: Chief Examiner

- (i) Identify the stages of mitosis represented by cells Y and Z.

Y Metaphase

Z Anaphase

[2]

- (ii) Describe **two** events which would take place in the cell immediately after the stage shown in cell Z.

1. The chromosomes decondense, becoming longer, thinner and less visible.

2. The nuclear membrane (envelope) reforms around each set of chromosomes.

[2]



6 (a) Osmosis is important in maintaining the water balance in plant and animal cells.

(i) Define the term 'osmosis'.

The movement of water through a selectively permeable membrane

from a solution of higher (less negative) water potential to a solution

of lower (more negative) water potential.

[1]

In certain types of throat infection, the cells lining the throat become swollen due to excess water. Rinsing the mouth and throat (gargling) with salt water is a traditional remedy to relieve the pain caused by this swelling.

(ii) With reference to osmosis, suggest how gargling with salt water could relieve this pain.

The salt solution has a lower (more negative) water potential than

the swollen cells lining the throat.

So excess water leaves the cells by osmosis, down the water potential

gradient, reducing the swelling and the pain.

[2]

[Turn over]



(b) Fluids can be transported into a cell by pinocytosis.

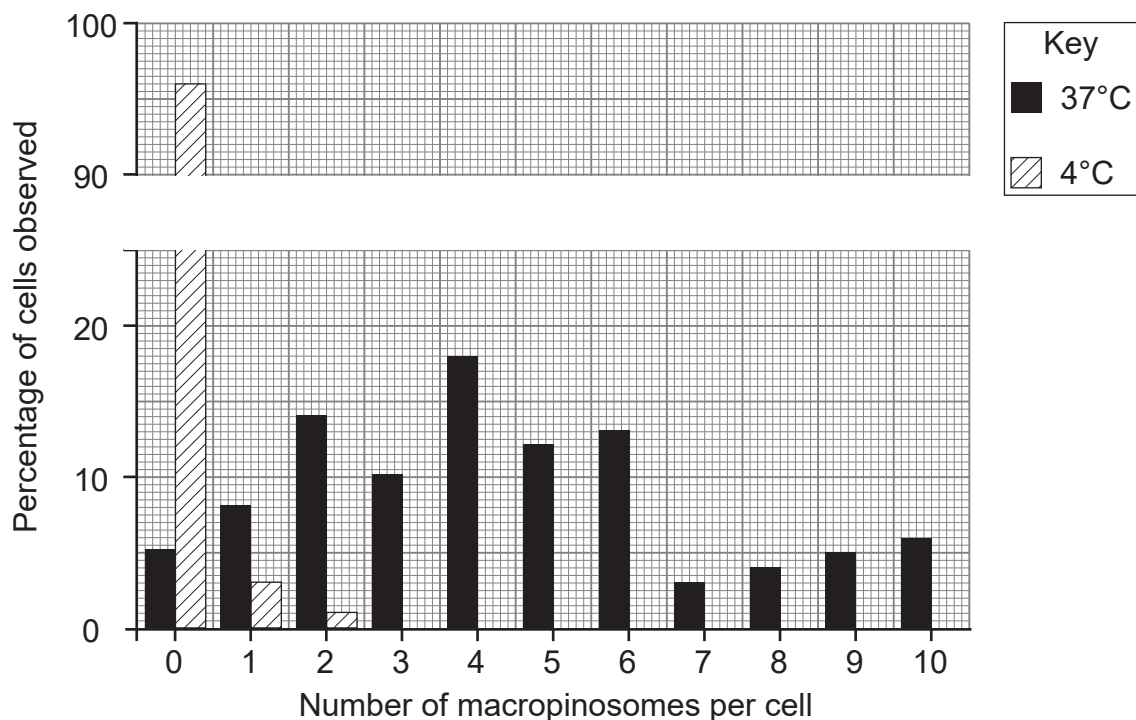
(i) Describe fully the process of pinocytosis.

The cell (plasma) membrane invaginates (folds inwards) around a droplet of extracellular fluid, forming a vesicle which pinches off and enters the cell (into the cytoplasm).

[2]

The fluid taken into a cell by pinocytosis is contained within a sac called a 'macropinosome'.

In an investigation, scientists studied the effect of temperature on pinocytosis. Their results are summarised in the graph below.



Source: © Charpentier, J.C., Chen, D., Lapinski, P.E. et al. Macropinocytosis drives T cell growth by sustaining the activation of mTORC1. Nat Commun 11, 180 (2020). <https://doi.org/10.1038/s41467-019-13997-3> <https://creativecommons.org/licenses/by/4.0/>



(ii) State the mode for number of macropinosomes per cell at 37°C.

4

[1]

(iii) Summarise the results shown for 4°C and for 37°C.

4°C Most cells (about 96%) had no macropinosomes,
and the maximum number of macropinosomes per cell was only 2.

37°C There was a much wider range, from 0 to 10 macropinosomes
per cell,
and the majority of cells had between 2 and 6 macropinosomes
(mode of 4).

[4]

Mammals have body temperatures of approximately 37°C.

(iv) Using the information provided and your knowledge, suggest an advantage of mammals maintaining a body temperature of 37°C.

More pinocytosis occurs at 37 °C, so more fluid (and dissolved
substances) can be taken into the cells.

[1]

[Turn over



Section B

Quality of written communication will be assessed in this section.

7 Plant and animal cells each have a plasma membrane.

In addition, many membranes are found within cells, where they have a variety of roles as part of membrane systems or organelles.

Outline the structure of the plasma membrane and briefly describe the variety of roles performed by membranes within cells.

[15]

Outline the structure of the plasma membrane and briefly describe the variety of roles performed by membranes within cells.

The plasma (cell surface) membrane is described by the fluid mosaic model.

It consists of a phospholipid bilayer with protein molecules scattered throughout it.

Each phospholipid has a hydrophilic phosphate head and two hydrophobic fatty acid tails. The hydrophilic heads face outwards, towards the aqueous cytoplasm and tissue fluid, while the hydrophobic tails point inwards, forming the core of the membrane.

Intrinsic proteins span the bilayer while extrinsic proteins are found on its surface. On the outer surface there is a glycocalyx made of glycoproteins and glycolipids. In animal cells, cholesterol is scattered throughout the membrane, regulating fluidity and providing stability.

The plasma membrane forms the boundary of the cell and regulates the movement of substances into and out of the cell, as it is selectively permeable. Its proteins have many roles: they act as channel and carrier



proteins for transport, as enzymes, as receptors for hormones and as antigens for cell recognition.

Within cells, the nucleus is surrounded by the nuclear membrane (envelope), a double membrane with pores. The outer membrane is encrusted with ribosomes and is the site of origin of the rough endoplasmic reticulum. The nuclear pores allow mRNA and ribosomes to pass out into the cytoplasm.

The rough endoplasmic reticulum (RER) is a system of membranes covered in ribosomes which provides the scaffolding for protein synthesis and transports the proteins made. The smooth endoplasmic reticulum (SER) has no ribosomes and is involved in the synthesis of lipids.

The Golgi apparatus is an organelle made of a stack of membrane-enclosed cisternae (flattened sacs) and vesicles, and it is involved in modifying proteins, for example adding carbohydrate to form glycoproteins, and packaging them.

Vesicles are membrane-surrounded sacs involved in transporting materials around the cell, for example from the Golgi apparatus to the plasma membrane for secretion.

Lysosomes are vesicles containing hydrolytic (cytolytic) enzymes. The lysosome membrane prevents these enzymes being released into the cytoplasm, where they would digest the cell.

Mitochondria have a double membrane and are the site of aerobic respiration.

The inner membrane is folded into cristae, which increase the surface area for

[Turn over



the enzymes of respiration.

In plant cells, chloroplasts also have a double membrane and are the organelles where photosynthesis takes place. Inside, the thylakoid membranes, stacked to form grana, contain the chlorophyll that absorbs light.

Finally, the large permanent vacuole of plant cells is surrounded by a membrane called the tonoplast, which separates the vacuole (cell sap) from the cytoplasm.

Therefore, membranes both form the boundary of the cell and divide it into compartments, so that different reactions can occur in separate organelles.





Handwriting practice lines consisting of 20 horizontal lines.

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Question Number	Marks
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Examiner Number

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