Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE AS

B400U10-1

S23-B400U10-1

MONDAY, 15 MAY 2023 – MORNING

BIOLOGY – AS component 1
Basic Biochemistry and Cell Organisation

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**18**	
2.	**17**	
3.	**23**	
4.	**8**	
5.	**9**	
Total	**75**	

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01

ADDITIONAL MATERIALS

In addition to this paper you may require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of quality of extended response (QER) will take place in question **5**.

The quality of written communication will affect the awarding of marks.

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Answer **all** questions.

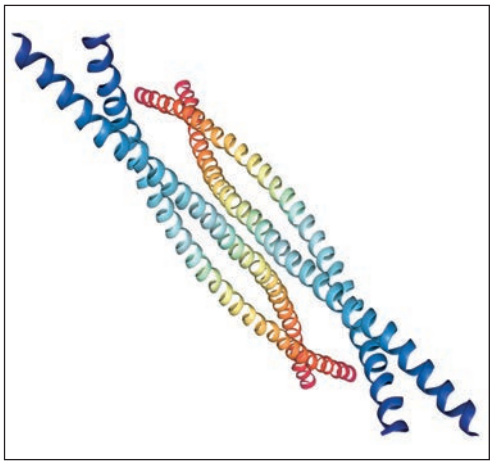
1. (a) Inorganic ions are found in many of the main biological molecules in living organisms. **Complete Table 1.1** to state **one** role of each of the inorganic ions shown. [2]

Table 1.1

Inorganic ion	Role in living organisms
Mg^{2+}	Component of chlorophyll, essential for photosynthesis
Fe^{2+}	Component of haemoglobin, for transport of oxygen
Ca^{2+}	Strengthens bones and teeth
PO_4^{3-}	Component of phospholipids, ATP and nucleic acids (DNA)

(b) Proteins are major biological molecules. The structures of keratin and lysozyme are shown in **Image 1.2**.

Image 1.2



Keratin



Lysozyme

(i) State **two** structural differences between the two types of proteins shown in **Image 1.2**. [2]

Keratin is a fibrous protein whereas lysozyme is a globular protein.

Keratin is helical (coiled) only, but lysozyme is folded and coiled, with alpha helices and beta pleated sheets.

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(ii) Polypeptides are polymers of amino acids joined by peptide bonds. Name the type of reaction which takes place to form these bonds. [1]

Condensation (reaction)

(iii) Lysozyme is an enzyme which functions in a way that supports the theory of the induced fit hypothesis. Describe the induced fit hypothesis. [4]

When the substrate binds, the active site changes shape to fit (mould around) the substrate.

An enzyme-substrate complex forms.

This puts strain on bonds in the substrate, lowering the activation energy of the reaction.

After the reaction the products are released and the active site returns to its original shape.

(iv) Describe how the lock and key hypothesis is different from the induced fit hypothesis. [2]

In the lock and key hypothesis the substrate already has a complementary shape to the active site.

The active site is rigid and does not change shape when the substrate binds.

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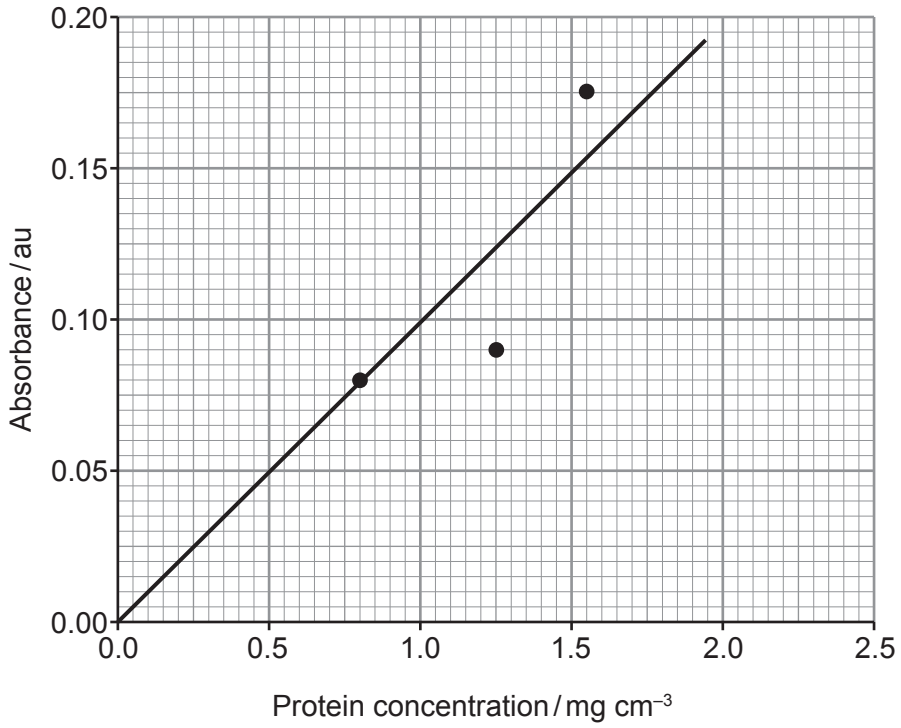
(c) Acid phosphatase (ACP) is an enzyme that catalyses the removal of an inorganic phosphate ion from a substrate by the induced fit model of enzyme action.

(i) The enzyme acid phosphatase is a protein. Name the reagent that would be used to test for protein **and** the colour produced by a positive result. [2]

Biuret reagent (copper sulfate and sodium hydroxide); a positive result turns lilac / purple.

The concentration of ACP in mung bean leaves of different ages was investigated. A standard curve was produced using three known concentrations of protein. The samples of protein were mixed with a reagent and the absorbance of light of the protein and reagent measured using a colorimeter. The standard curve is shown in **Graph 1.3**.

Graph 1.3



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Leaves of different ages were collected. Protein was extracted from the leaves and the sample placed with the reagent in a colorimeter. **Table 1.4** shows the concentration of protein found in the different leaf extracts.

Table 1.4

Age of leaf / days	Protein concentration / mg cm^{-3}
1	2.1
2	1.9
3	1.7
4	1.0
5	0.4
6	0.2

(ii) The extract from the day 5 leaf was tested and the absorbance was found to be 0.04 au. **Use the standard curve in Graph 1.3** to determine the protein concentration of the extract. **Write your answer in Table 1.4**. [1]

(iii) Explain why chlorophyll would need to be removed from the extract before the absorbance is measured. [1]

Chlorophyll would absorb the light in the colorimeter, so more light would be absorbed than by the protein alone.

(iv) Explain why this method would not allow the determination of the actual **acid phosphatase (ACP)** concentration. [1]

ACP is not the only protein present: the leaf extract contains other proteins as well, so the test measures total protein.

(v) Use evidence from **Graph 1.3** to explain **one** possible source of error with the method used to produce the standard curve. [2]

Not enough protein concentrations were used: only three points, which do not lie on the line (e.g. 0.09 au at 1.25 mg cm^{-3}).

So the line of best fit is not valid: it could be drawn in a number of places or be a curve. No repeats or range bars are shown.

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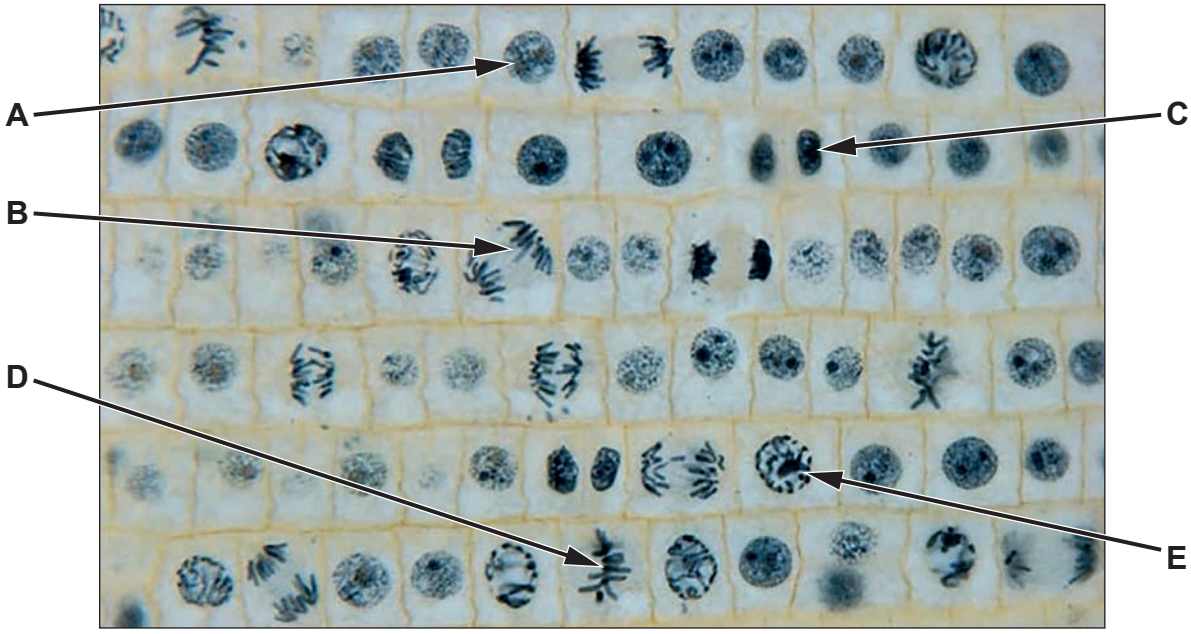
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2. Cell division was observed in the root tips of onions. The root tips were removed and prepared for viewing with the light microscope. The photomicrograph in **Image 2.1** shows cells in the root tip at ×400 magnification.

Image 2.1



(a) (i) State what was added to the tissue during preparation and explain why this was necessary. [2]

A stain, such as acetic orcein (toluidine blue), was added.

This was necessary to make the chromosomes visible, as they are colourless.

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(ii) Give **three** reasons why chromosomes cannot be seen in all cells in **Image 2.1**. [3]

Some cells are in interphase, where the chromosomes are decondensed (not yet condensed or coiled).

Some cells have finished cell division, so the chromosomes have uncoiled.

It depends where the section is cut (the plane or angle), so chromosomes may not be in the section, or some cells have not taken up enough stain.

(iii) Using letters **(A–E)** from **Image 2.1**, identify cells that match the descriptions of the stages in **Table 2.2**. [3]

Table 2.2

Description of the stage	Letter
The chromosomes condense	E
Pairs of chromatids are on the equator	D
The nuclear envelopes are being reformed	C
Replication of DNA is taking place	A
Chromatids being pulled to the poles	B

(iv) Identify the longest stage of the cell cycle. Use evidence from **Image 2.1** and your own knowledge to explain your answer. [2]

Interphase.

Most of the cells in Image 2.1 are in interphase (with a nucleus and no visible chromosomes), so the cell cycle spends the longest time in this phase.

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(b) The mitotic index can be calculated to show the number of cells undergoing mitosis. This can give an estimate of the growth rate at the root tip. The number of cells undergoing mitosis were counted at different distances from the root tip. The results are shown in **Table 2.3**.

Table 2.3

Distance from the root tip / μm	Total number of cells in field of view	Total number of cells in mitosis	Mitotic index / %
200	57	7	12.3
500	49	4	8.2
1500	53	1	1.9
2000	54	0	0

(i) Calculate the mitotic index for 500 μm from the root tip. **Write your answer in Table 2.3**. [2]

Space for working

mitotic index = (cells in mitosis ÷ total cells) × 100

= (4 ÷ 49) × 100 = 8.16 = 8.2 %

(ii) Suggest how you could increase the reliability of the method for calculating the mitotic index of this root tip. [2]

Count the cells in more fields of view at each distance (or repeat the experiment with more root tips).

Then calculate a mean mitotic index for each distance.

(iii) Explain the significance of mitotic cell division to living organisms. [3]

Mitosis produces genetically identical daughter cells.

It is used for growth of the organism, such as at the root tip.

It is used for repair of tissues and replacement of damaged or worn out cells.

It is used in asexual reproduction.

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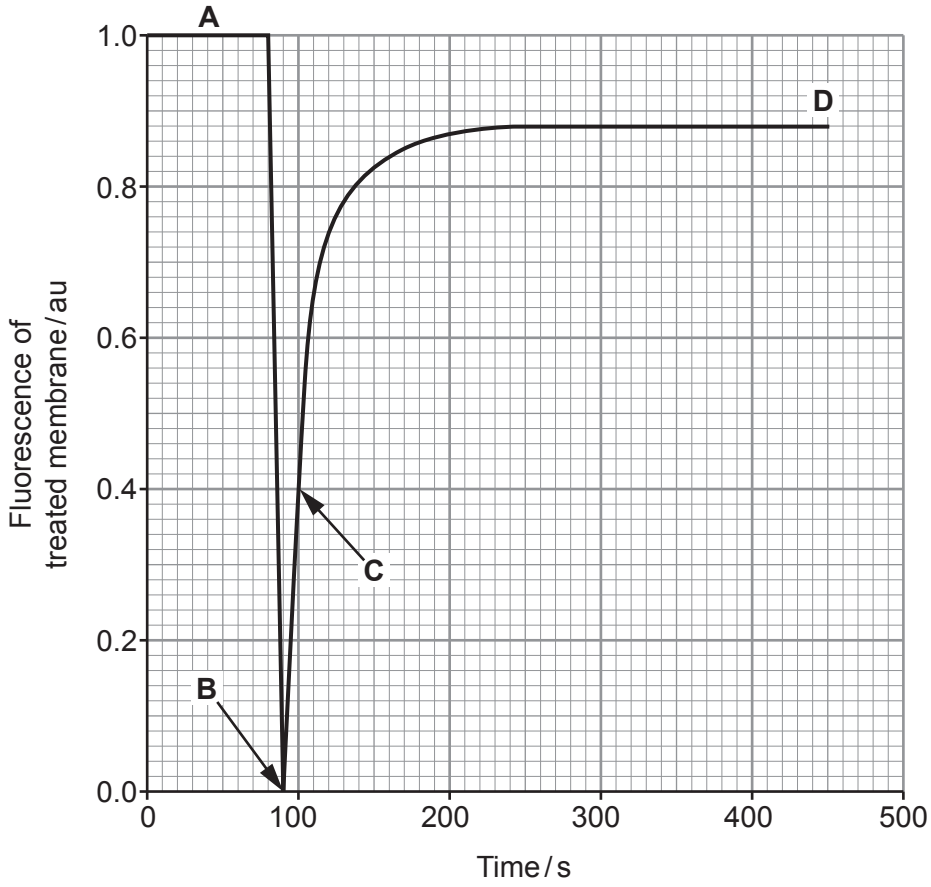
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3. (a) Cell membranes are composed of a double layer of phospholipids.
An experiment was carried out to investigate the positioning of phospholipids in the membrane of a living cell. All phospholipids in the membrane were labelled with a fluorescent marker dye. When the marker dye absorbed light, it stopped fluorescing. The membrane in the area exposed to light then appeared as a dark spot. The level of fluorescence of the membrane over a period of time is shown in **Graph 3.1**.

Graph 3.1



(i) Use **one** of the letters **(A–D)** shown on **Graph 3.1** to suggest when the cell membrane was exposed to the light and explain your answer. [1]

Point B, as the fluorescence has fallen to 0 au, so the phospholipids in the area exposed to light are not fluorescing.

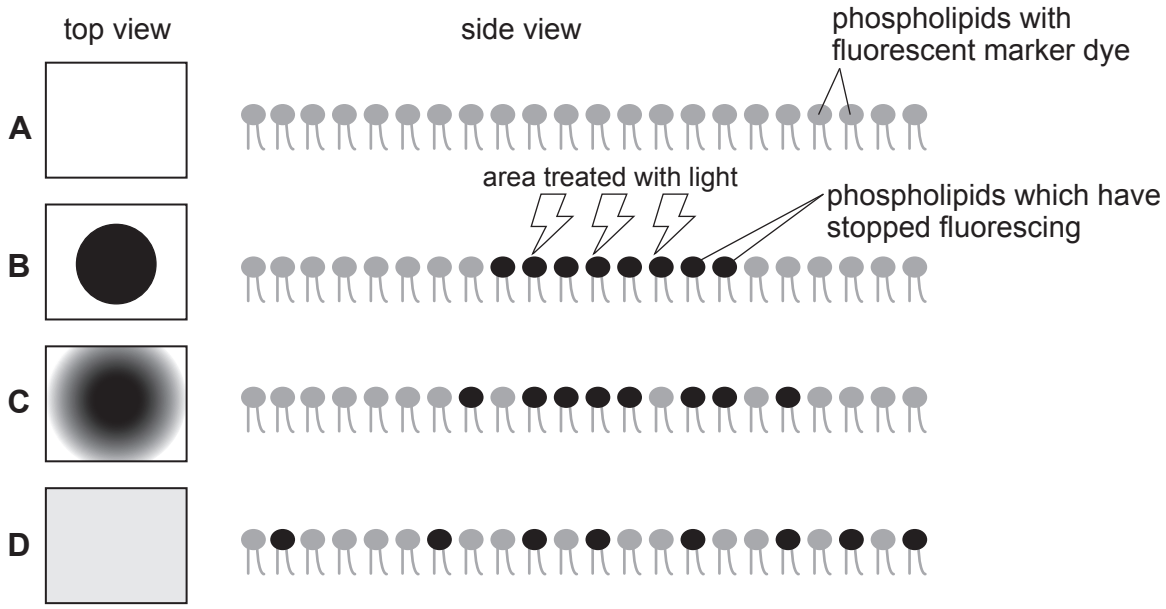
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Image 3.2 shows the top and side view of an area of the membrane before, during and after exposure to a light source.

Image 3.2



(ii) Use the results shown in **Graph 3.1 and Image 3.2** and your knowledge of membrane structure to explain the recovery of the fluorescence. [3]

Fluid mosaic model: the phospholipids are not bound together and can change position.

The dark spot disappears (C to D) as non-fluorescing phospholipids move out of the area and fluorescent ones move in.

Fluorescence does not return to its original level (0.88 au, not 1.0 au).

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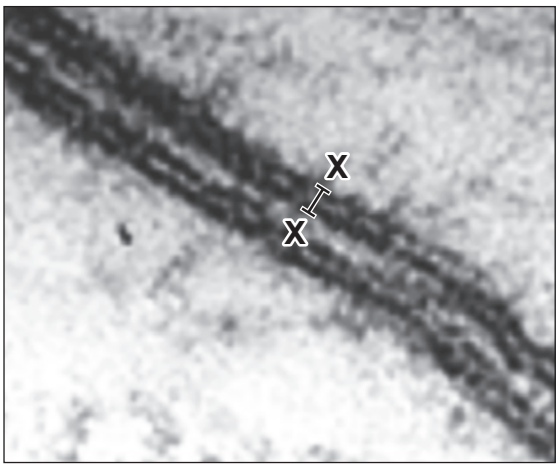
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(b) **Image 3.3** shows an electron micrograph of the plasma membranes of two adjacent cells.

Image 3.3



(i) Use only the **scale bar** to calculate the magnification of **Image 3.3**. [2]

scale bar = 13 mm = 13 000 000 nm

M = 13 000 000 ÷ 25 = 520 000

Magnification = × *520 000*

(ii) Use your answer from (i) to calculate the actual width of the plasma membrane shown by **X–X**. **Express your answer to two significant figures**. [2]

X–X = 4 mm = 4 000 000 nm

A = 4 000 000 ÷ 520 000 = 7.69 nm

Actual width = *7.7* nm

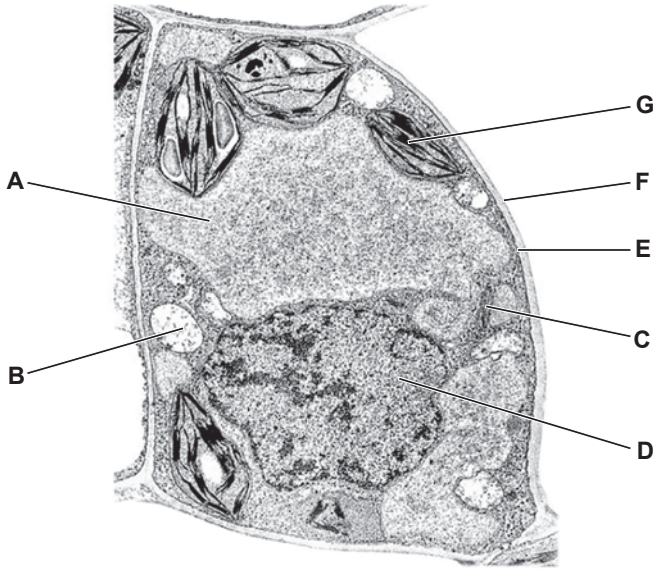
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(c) **Image 3.4** is an electron micrograph of a plant cell showing some organelles.

Image 3.4



Using letters **(A–G)** from **Image 3.4**, identify the organelles in **Table 3.5**. [2]

Table 3.5

Organelle	Letter
Chloroplast	G
Nucleus	D
Vacuole	A

(d) The effect of sodium chloride concentration on membrane structure was studied using beetroot cells. Beetroot cells contain a red pigment called betalain which is released when the membrane structure is disrupted. A temperature of 30 °C disrupts the membrane structure and allows the pigment to escape from the cell.

The method used to study the membrane structure is shown below:

Method

- Samples of beetroot were added to test tubes containing a range of sodium chloride solutions.
- They were left for five minutes at 30 °C.
- A sample of the liquid was then placed in a cuvette.
- The absorbance of light was recorded using a colorimeter.

(i) Suggest why the temperature would need to be controlled in this experiment. [2]

Temperature affects the kinetic energy of the molecules: higher temperatures would disrupt the membrane and allow more pigment to escape.

High temperatures could also denature the membrane proteins.

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The results of the investigation are shown in **Table 3.6**.

Table 3.6

NaCl concentration /%	Absorbance of betalain solution / au			
	Trial 1	Trial 2	Trial 3	Mean
0.1	0.49	0.52	0.48	0.50
0.2	0.26	0.26	0.27	0.26
0.3	0.14	0.20	0.15	0.16
0.4	0.09	0.10	0.08	0.09
0.5	0.03	0.01	0.03	0.02

(ii) Calculate the mean absorbance for 0.3% NaCl solution. **Write your answer in Table 3.6**. [1]

(iii) Use the data in **Table 3.6** to describe and explain the effect of increasing the concentration of the NaCl solution on the permeability of the beetroot membrane. [4]

As the NaCl concentration increases, the absorbance decreases, from a mean of 0.50 au at 0.1% to 0.02 au at 0.5% NaCl.

Lower absorbance means less betalain pigment has been released from the cells.

So the more NaCl, the less permeable the beetroot membrane becomes.

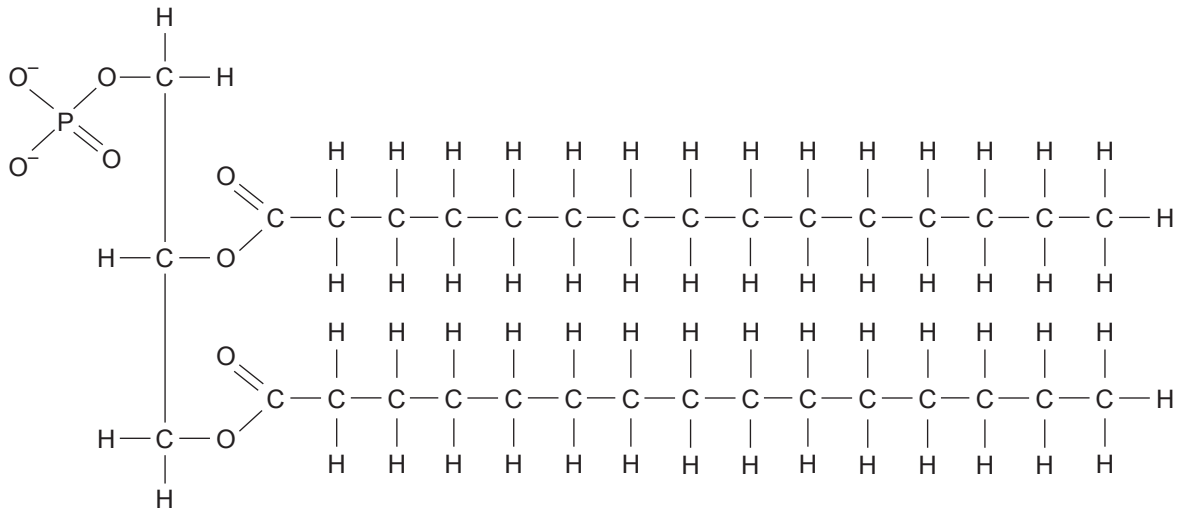
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Image 3.7 shows the structure of a phospholipid.

Image 3.7



(iv) When dissolved in water, NaCl dissociates to form Na^+ and Cl^- ions. Use the structure shown in **Image 3.7** and the data in **Table 3.6** to suggest how the interaction between the Na^+ ions and the phospholipid affects the fluidity of the membrane. [4]

The Na^+ ions are attracted to the negative charges (O^-) on the phosphate heads of the phospholipids, as they have opposite charges. With more Na^+ there is less movement of the phospholipids, as they are held together. This stabilises the membrane, making it less fluid and more rigid. So less pigment can escape, which is why absorbance falls as NaCl concentration increases.

(v) Suggest how the method could be modified to investigate the effect of temperature on membrane stability. [2]

Use a range of temperatures, such as 20, 30, 40, 50 and 60 °C, with water baths. Keep the NaCl concentration the same in every tube, such as 0.1% NaCl.

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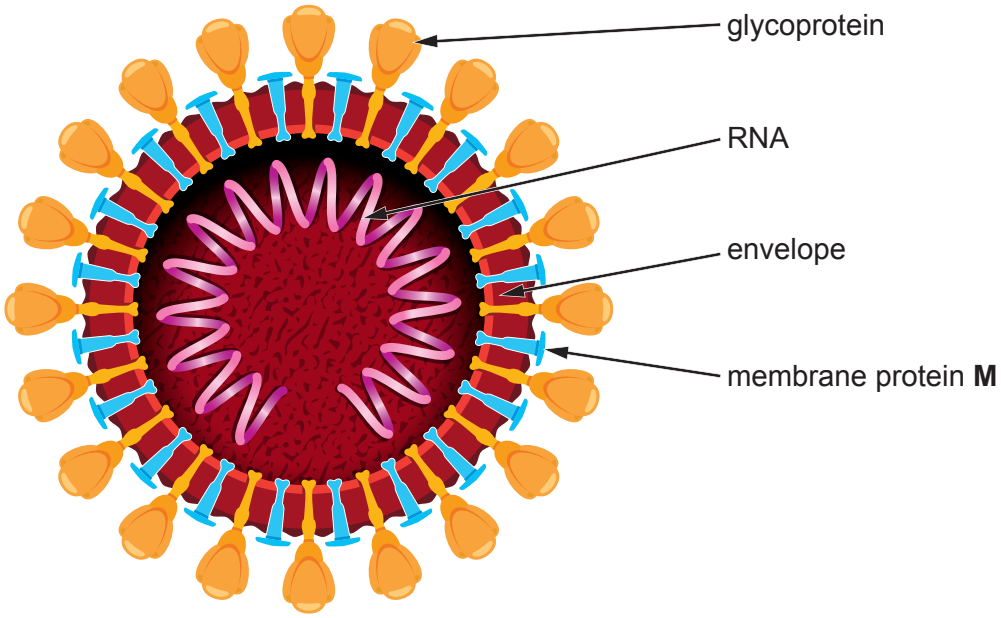
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4. SARS is a type of virus which causes a respiratory disease. **Image 4** shows the structure of the virus. All viruses contain a nucleic acid within their core and are surrounded by a protein coat called a capsid.

The SARS virus infects human cells and takes over the cells' metabolism. It is replicated by the human cells, which make the viral proteins using the same organelles as they would for normal protein synthesis within a cell.

Image 4



(a) The genetic material within the SARS virus is RNA. State **two** ways in which the structure of RNA differs from DNA. [2]

RNA contains uracil rather than thymine.

RNA is single stranded rather than double stranded (a double helix).

RNA contains ribose sugar rather than deoxyribose.

(b) Membrane protein **M** is coded for by a section of the viral RNA. This section of the viral RNA is used to form a complementary mRNA molecule in the cytoplasm of the host cell. This mRNA is then processed in a similar way to host cell mRNA.

(i) Part of the viral RNA is shown below. **Write the sequence of bases** for the complementary mRNA molecule formed from the viral RNA. [1]

Viral RNA	A	U	G	G	C	C	A	G	U	U	A	A
Complementary mRNA	U	A	C	C	G	G	U	C	A	A	U	U

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(ii) Using your own knowledge of protein synthesis suggest how the host cell uses the mRNA to produce viral membrane protein **M**. [5]

Translation: the mRNA attaches to a ribosome (on the rough ER).

tRNA brings a specific amino acid to the ribosome.

The tRNA anticodon pairs with the complementary mRNA codon (complementary base pairing).

The ribosome holds two tRNA molecules, bringing two amino acids close together.

A peptide bond forms between them by a condensation reaction.

The ribosome moves to the next codon, until a stop codon is reached.

The polypeptide is folded and processed in the Golgi body to form protein M.

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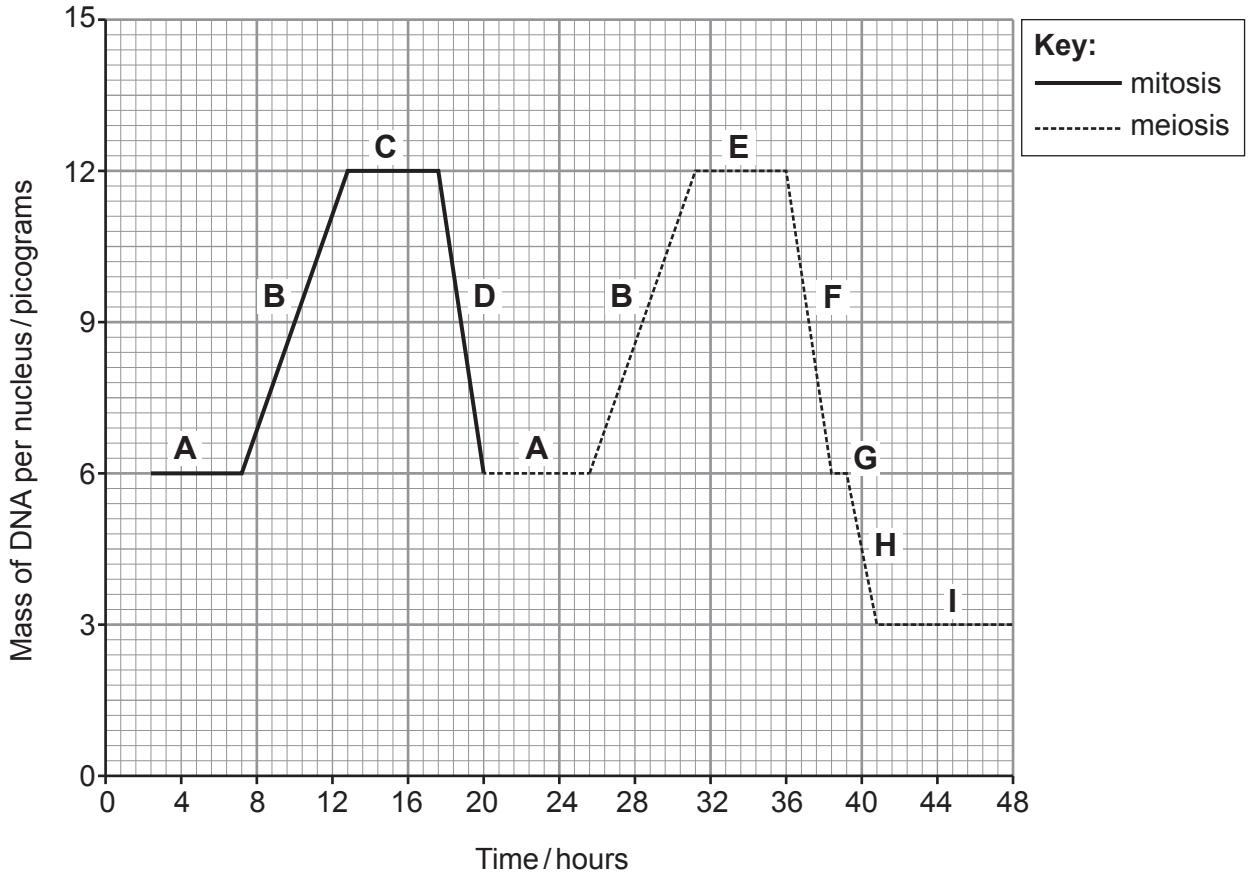
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5. Cells within the human male testes produce sperm through the processes of mitosis and meiosis.

Graph 5 shows the mass of DNA found in the nucleus of one of these cells as it undergoes mitosis and then meiosis to form a single sperm cell. The letters (**A–I**) indicate stages before and during cell division by mitosis and meiosis.

Graph 5



Use the information in **Graph 5** and your knowledge of cell division to explain the changes in the DNA mass of the nucleus for both mitosis and meiosis. Explain how meiosis increases the genetic variation of offspring. [9 QER]

Mitosis: at A the nucleus contains 6 pg of DNA. During B (interphase, S phase) the DNA mass doubles from 6 pg to 12 pg because the DNA is replicated, so each chromosome is made of two identical sister chromatids. At C the DNA mass stays at 12 pg while the chromosomes condense and line up on the equator. At D the DNA mass returns to normal (6 pg) because the chromatids are separated in anaphase and pulled to opposite poles, and two

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nuclei form at telophase followed by cytokinesis.

The daughter cells have the same mass of DNA (6 pg) as the initial cell and are genetically identical (clones), as each receives one copy of every chromosome.

Meiosis: one of these cells then undergoes meiosis. During B the DNA mass again doubles from 6 pg to 12 pg because of replication. At F (anaphase I) the homologous chromosomes are separated, so the DNA mass drops to 6 pg, half of the original replicated mass.

At G (anaphase II) the sister chromatids are separated, so the DNA mass halves again and drops to 3 pg (H and I). The original cell is diploid, but the four daughter cells (sperm) produced are haploid, with half the chromosome number and half the DNA of a body cell.

Significance of meiosis: because the gametes are haploid, the chromosome number remains constant in each generation when two gametes fuse at fertilisation to form a diploid zygote.

Meiosis also introduces genetic variation. In prophase I homologous chromosomes pair up (bivalents) and crossing over occurs at chiasmata, where sections of non-sister chromatids are exchanged, producing new combinations of alleles.

In metaphase I there is independent assortment: the homologous pairs line up randomly on the equator, so each gamete receives a different combination of maternal and paternal chromosomes. Independent assortment of chromatids at metaphase II adds further variation.

Random fertilisation of these genetically different gametes means each offspring is genetically unique. This variation allows some individuals to survive in a changing environment, so the species can adapt through natural selection.

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