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

GCE AS

B400U10-1

S25-B400U10-1

MONDAY, 12 MAY 2025 – MORNING

BIOLOGY – AS component 1
Basic Biochemistry and Cell Organisation

1 hour 30 minutes

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Question	**Maximum Mark**	**Mark Awarded**
1.	**13**	
2.	**9**	
3.	**15**	
4.	**16**	
5.	**13**	
6.	**9**	
Total	**75**	

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ADDITIONAL MATERIALS

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 **6**.

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

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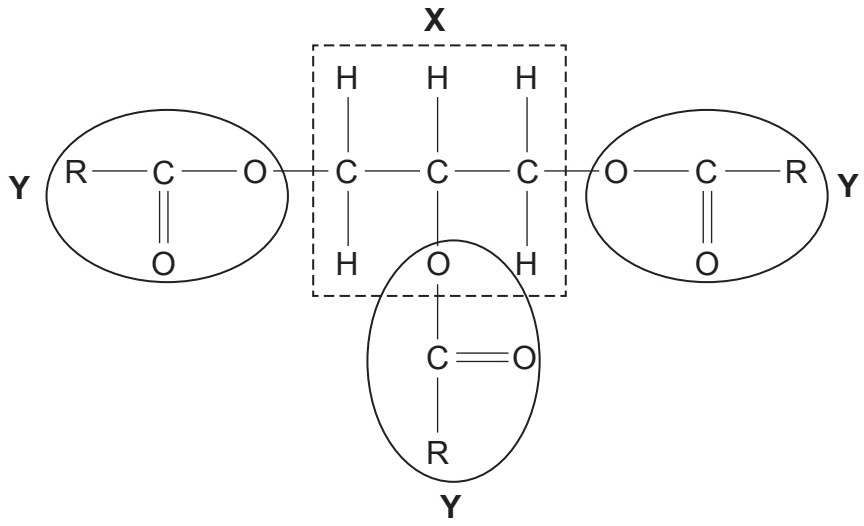
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Answer **all** questions.

1. Lipids have many functions in organisms. Molecules of lipids are formed by combining several other molecules. The general structure of one type of lipid is shown in **Image 1.1**.

Image 1.1



(a) The lipid shown in **Image 1.1** was formed by condensation reactions between molecule **X** and three of the molecules labelled **Y**.

(i) State the names of the molecules labelled **X** and **Y** in **Image 1.1**. [1]

X *glycerol*

Y *fatty acid*

(ii) With reference to **Image 1.1**, explain why up to four **structurally different** molecules could be combined to form a lipid of this type. [2]

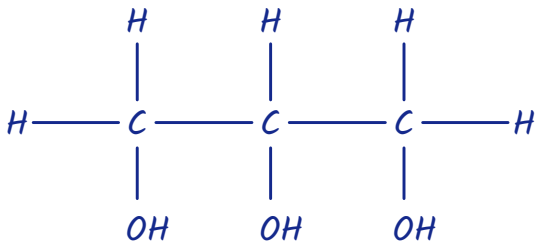
R is a variable group, so each of the three fatty acids (Y) can have a different R group (up to three different fatty acids), and all three are bonded to the same glycerol (X): glycerol plus three different fatty acids.

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(iii) Draw the structural formula of the molecule labelled **X** in **Image 1.1 before** the condensation reactions took place. [1]



(b) **Table 1.2** gives information on four different molecules that could be molecule **Y** in **Image 1.1**.

Table 1.2

	Formula of molecule **Y**	Melting point /°C	Saturated or unsaturated	Solid or liquid at room temperature
A	$C_{17}H_{35}COOH$	69.6	Saturated	solid
B	$C_{17}H_{33}COOH$	13.0	Unsaturated	liquid
C	$C_{17}H_{31}COOH$	-5.0	Unsaturated	liquid
D	$C_{17}H_{29}COOH$	-14.5	Unsaturated	liquid

(i) Complete **Table 1.2** to show whether molecules **A** to **D** would be **solid** or **liquid** at a room temperature of 20 °C. [1]

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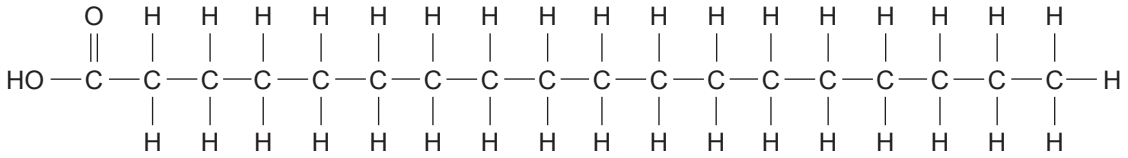
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(ii) **Image 1.3** shows the structural formula of molecule **A**.

Image 1.3



Use the formulae from **Table 1.2** and **Image 1.3** to explain the classification of molecules **A** to **D** as being saturated or unsaturated. [3]

A ($C_{17}H_{35}COOH$) has only single C–C bonds in its hydrocarbon chain, so it holds the maximum number of hydrogen atoms (Image 1.3): it is saturated.

B, C and D have the same number of carbon atoms but fewer H atoms (33, 31 and 29), so they must have C=C double bonds (B one, C two, D three): they are unsaturated.

(iii) Suggest and explain how eating lipids containing only molecule **D** in **Table 1.2** may impact human health. [2]

D is (poly)unsaturated, so eating it lowers the level of low density lipoprotein (LDL) and cholesterol in the blood (and increases HDL). This lowers the incidence of atheromas, so lowers the risk of heart disease (CHD).

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(iv) In order to improve human health, people who drink milk have been advised to drink skimmed or plant-based milks.

I. Describe how ethanol can be used to show the presence of lipid in a food sample. [2]

Mix and shake the food sample with ethanol (no heating), then pour the ethanol into a test tube of cold water.

A cloudy white emulsion forms if lipid is present.

II. Explain why this test cannot be used to test for lipid in milk. [1]

Milk is already a white emulsion, so the emulsion would be the same colour as the milk.

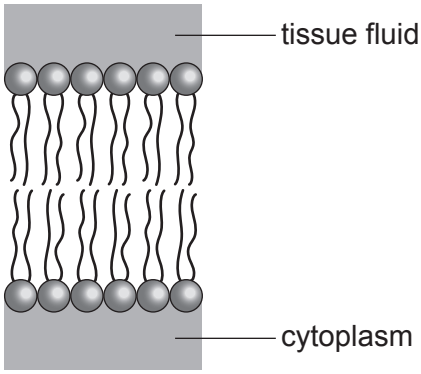
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2. Cell membranes contain phospholipids. **Image 2.1** shows a simplified drawing of the arrangement of phospholipids in a cell membrane.

Image 2.1



(a) With reference to the properties of phospholipids and water, describe and explain the arrangement of phospholipids in a cell membrane as shown in **Image 2.1**. [4]

The phospholipids form a bilayer. The tissue fluid and the cytoplasm both contain water, and water is a polar molecule.

The phosphate heads are hydrophilic (polar), so they are attracted to water: they face outwards, in contact with the water in the tissue fluid and cytoplasm.

The fatty acid tails are hydrophobic (non-polar), so they are repelled by water: they point inwards and are in the middle of the bilayer, away from the water.

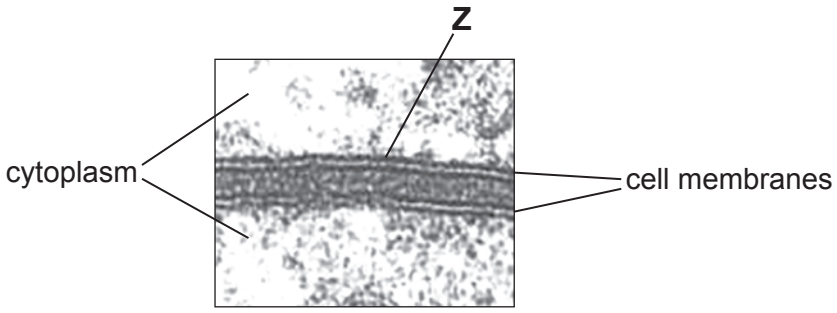
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(b) **Image 2.2** shows the appearance of a section through the cell membranes of two adjacent cells at high magnification using an electron microscope.

Image 2.2



(i) The currently accepted model of the cell membrane structure is called the fluid mosaic model. Phospholipids are the main component of cell membranes.

State the name of a molecule that increases the stability of animal cell membranes. [1]

cholesterol

(ii) At the point labelled **Z** on **Image 2.2**, the actual thickness of the cell membrane was found to be 7.5 nm. On the original photomicrograph, the thickness of the cell membrane was 0.8 mm.

Calculate the magnification of the photomicrograph.
Give your answer to **two significant figures** in **standard form**. [3]

0.8 mm = 0.8 × 10^6 nm = 800 000 nm

magnification = image size ÷ actual size

= 800 000 ÷ 7.5 = 106 667 = 1.07 × 10^5

Magnification = × *1.1 × 10^5*

(iii) Fick's Law states that:

$$\text{Rate of diffusion} = \frac{\text{surface area of exchange surface} \times \text{difference in concentration}}{\text{thickness of exchange surface}}$$

State how an increase in the thickness of the cell membrane would affect the rate of diffusion. [1]

The rate of diffusion would decrease.

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3. Phenolphthalein is a pH indicator that is pink in alkaline solutions but colourless in neutral or acid conditions.

An investigation was carried out to determine the optimum temperature of the enzyme lipase. In this investigation, fatty acids are released by the digestion of the fats found in milk. This lowers the pH and causes a colour change.

Method

1 Add 5 cm^3 of milk, 0.5 cm^3 of phenolphthalein and 4 cm^3 of sodium carbonate solution to a boiling tube.
2 Place the boiling tube in a thermostatically controlled water bath at 25 °C.
3 Add 1 cm^3 of lipase solution to a test tube.
4 Place the test tube in the same water bath.
5 After 10 minutes, pour the lipase solution into the boiling tube and start a stop clock.
6 Record the time taken for the solution to lose its pink colour.
7 Repeat steps 1–5 to obtain two further results at this temperature.
8 Repeat the experiment using water baths set at 15 °C, 35 °C, 45 °C and 75 °C.

(a) (i) State **two** variables which were controlled in this investigation. [1]

Volume of milk and volume of lipase solution (also volumes of phenolphthalein and sodium carbonate).

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(ii) Explain why the investigation would be invalid if **steps 2** and **4** in the method were not followed. [1]

The temperature would not be constant, so molecules would have different kinetic energy, affecting the rate of reaction.

(iii) Identify the **main** source of inaccuracy in this investigation. [1]

The colour change is subjective; it is difficult to judge the end-point (loss of pink colour).

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(b) The results of the investigation are shown in **Table 3.1**.

Table 3.1

Temperature of water bath /°C	Time taken for solution to lose its pink colour / s			
	Trial 1	Trial 2	Trial 3	Mean
15	65	64	61	63.3
25	48	46	45	46.3
35	38	41	37	38.7
45	26	28	29	27.7
75	102	114	109	108.3

(i) Calculate the mean for **15 °C**. Write your answer in **Table 3.1**. [1]

(ii) Plot a graph of the mean results on **Graph 3.2**. Range bars are not required. [4]

(iii) I. Explain why it is not possible to identify the optimum temperature for the lipase used in this experiment using the method outlined. [2]

The temperature intervals are too large: no temperatures were tested between 45 °C and 75 °C.

The time could continue to decrease above 45 °C, so the shortest time (optimum temperature) could lie between 45 °C and 75 °C.

II. Suggest how you could modify the method to enable more accurate determination of the optimum temperature. [1]

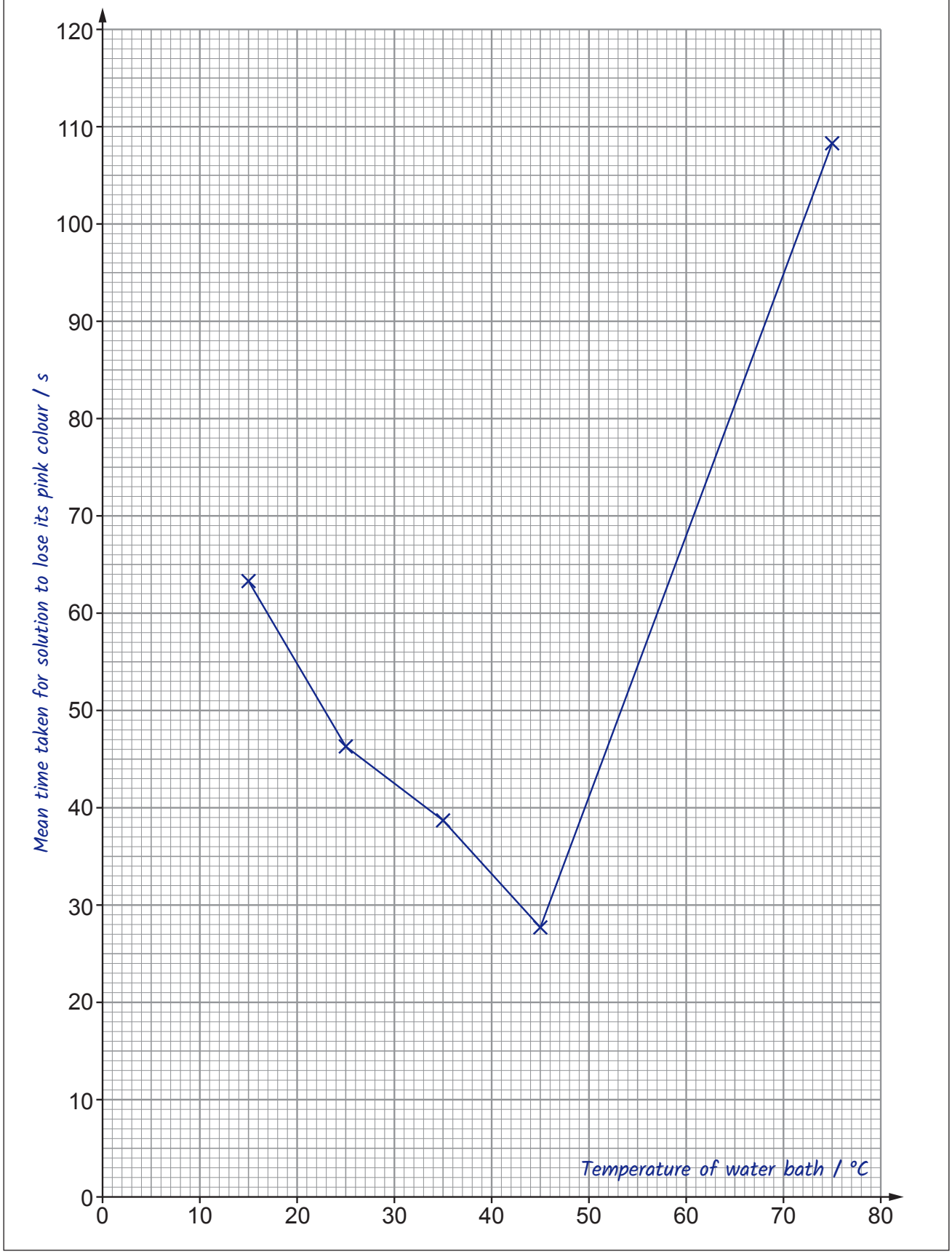
Repeat using water baths at temperatures between 45 °C and 75 °C, at 5 °C intervals (50, 55, 60, 65, 70 °C).

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Graph 3.2



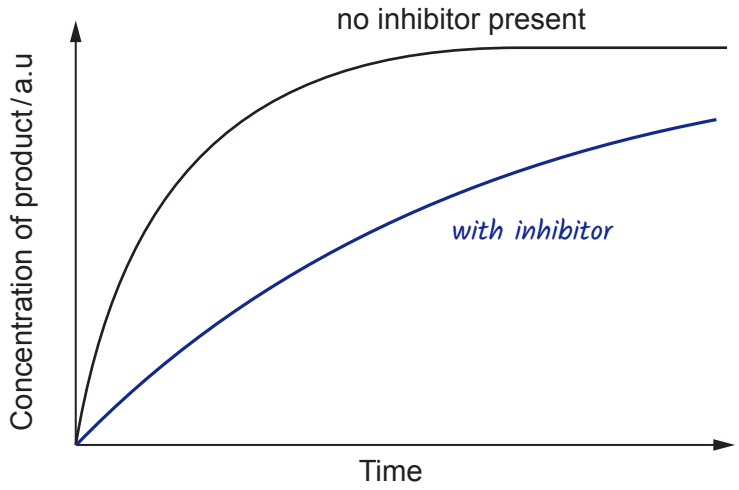
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(c) **Graph 3.3** shows how the **concentration of product** changed in this experiment over time.

Graph 3.3



(i) **Draw a line** on **Graph 3.3** to show the effect of the presence of a low concentration of a **non-competitive inhibitor** of lipase on the **concentration of product**. [1]

(ii) Use your knowledge of non-competitive inhibitors to explain why you have drawn the line in that position. [3]

A non-competitive inhibitor binds to the enzyme at an allosteric site (away from the active site), which changes the shape of the active site. The substrate (lipid) cannot bind, so fewer enzyme-substrate complexes form: fewer enzymes are available to break down the lipid. So it takes longer to make the product: the line is less steep but still rising.

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4. There are many definitions of what is meant by a living organism.
Read the definitions below and then answer the questions that follow.

Definition A:
An organism is considered as living when it performs the different life processes in one form or another. These include nutrition, movement, growth, reproduction, respiration, sensitivity and excretion.

Definition B:
A living organism is an individual form of life composed of one or more cells containing organelles which work together to carry out different life processes.

Definition C:
A living organism is any biological entity capable of transferring or replicating genetic material.

(a) (i) Explain why definitions **A** and **B** would not include viruses as being living organisms. [2]

A: viruses do not carry out life processes themselves; they rely on host cells for protein synthesis and replication of their DNA or RNA.

B: viruses have no cell membrane, cytoplasm or organelles: they are not cells.

(ii) Suggest why definition **C** would include viruses as living organisms. [1]

Viruses can transfer their genetic material into a host cell and be replicated by the host cell.

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(b) Definition **A** lists several different life processes which are said to be characteristics of a living organism. In unicellular organisms, each of these life processes must take place within a single cell.

Since the appearance of the first living organisms on Earth, two different cell types have evolved, prokaryotic and eukaryotic.

Complete **Table 4.1** to identify where some of the life processes listed in Definition **A** take place in these types of cells. [3]

Table 4.1

Life process	Where the life process takes place in a cell	
	prokaryote	eukaryote
synthesis of most ATP during respiration	cytoplasm / mesosomes	mitochondria
synthesis of proteins for growth and metabolism	ribosomes	ribosomes
replication of DNA during asexual reproduction	cytoplasm	nucleus

Question continued overleaf

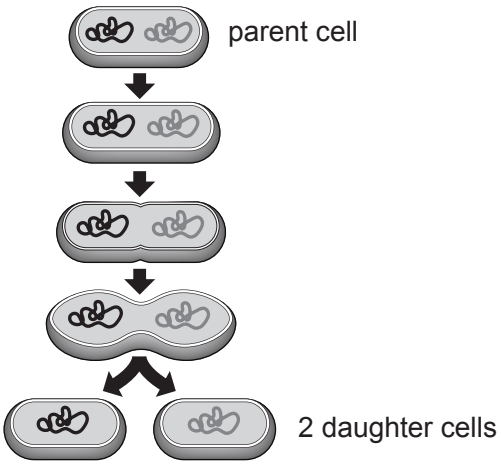
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(c) Prokaryotic cells reproduce asexually by a process called binary fission. Unicellular eukaryotes reproduce asexually by mitosis.

Image 4.2 shows stages in binary fission following DNA replication.

Image 4.2



(i) State **one** way in which the daughter cells produced in meiosis differ from those produced in binary fission and mitosis. [1]

Meiosis produces four daughter cells that are genetically different.

(ii) Explain why binary fission is not the same as mitosis. [1]

Prokaryotes have no nucleus or chromosomes, and binary fission does not involve a spindle apparatus.

(iii) The process of cell division can be observed using a light microscope at a high magnification.

I. Suggest why an objective lens of a higher magnification would be needed to observe the division of prokaryotic cells than would be needed to observe eukaryotic cells. [1]

Prokaryotic cells are much smaller (about ×10 smaller) than eukaryotic cells.

II. Explain why a microscope needs to be recalibrated when using different objective lenses. [1]

The value of one eyepiece graticule unit (epu) is different at each magnification.

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(d) A cell undergoing mitosis was observed and the following measurements taken over a 30-minute period:

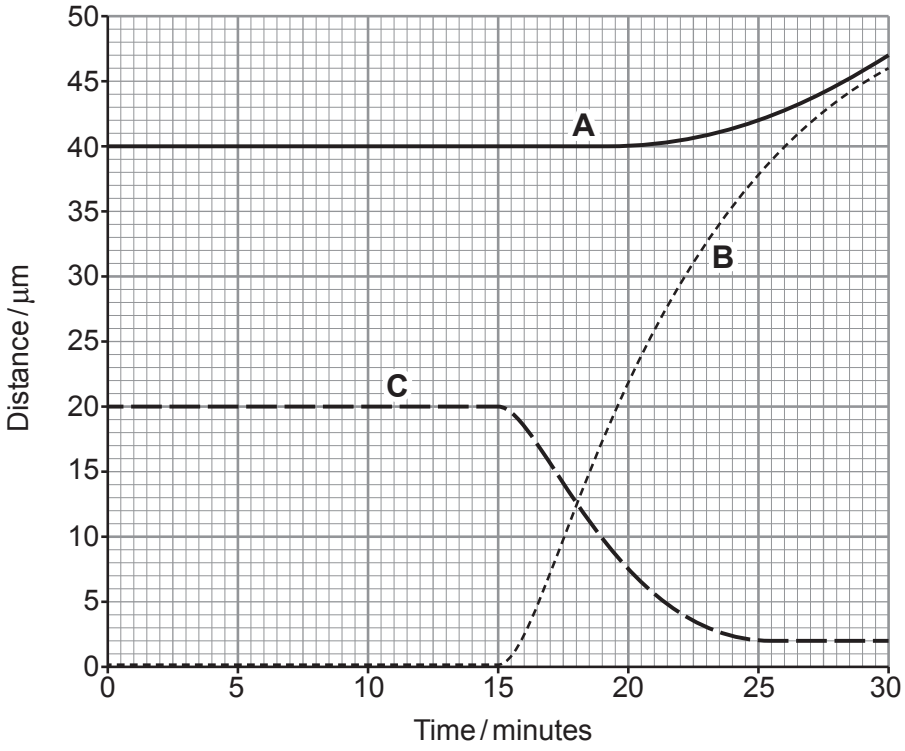
A the distance between the poles of the spindle apparatus

B the distance between the centromeres of sister chromatids

C the distance between the centromeres and the poles of the spindle.

Graph 4.3 shows how each of these distances changed over the 30 minutes of observation.

Graph 4.3



Use your knowledge of mitosis and the information shown in **Graph 4.3** to answer the following questions.

(i) Conclude when anaphase started in this cell. Explain your answer. [2]

15 minutes: here the distance between centromeres of sister chromatids (B) starts to increase and centromere to pole distance (C) starts to decrease, as chromatids are pulled to opposite poles.

(ii) Suggest what stage of mitosis is taking place between 20 and 30 minutes. [1]

Telophase.

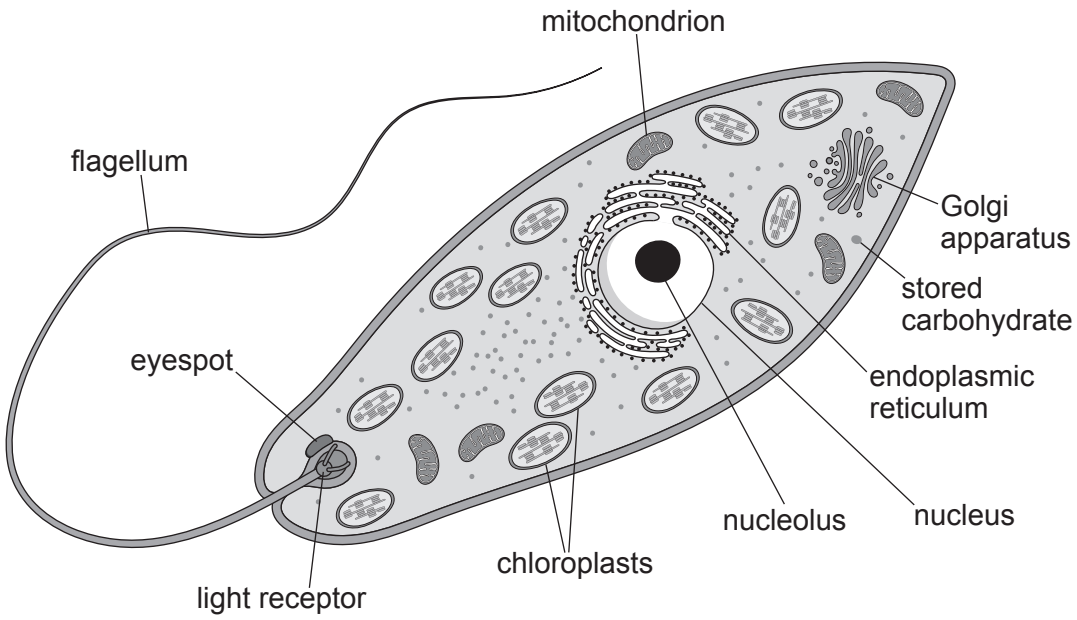
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(e) **Image 4.4** shows a diagram of a unicellular organism called *Euglena*.

Image 4.4



(i) Use information from **Image 4.4** to explain why *Euglena* has, at different times, been classified as a plant and as an animal. [2]

Plant

It contains chloroplasts, so it can photosynthesise like a plant.

Animal

It has a flagellum so it can move itself, and an eyespot (light receptor) to detect light.

(ii) Suggest into which Kingdom *Euglena* may be classified. [1]

Protoctista (protist).

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5. Motor neurone disease (MND) is a progressive condition that affects the function of the nervous system.

Researchers have identified a protein called FUS which is vital for nerve cells to work properly.

(a) **Image 5.1** shows a section of mRNA that codes for six amino acids in the FUS protein.

Image 5.1

--------- **AUG CCG GCA CGG AUU CUG** ---------
met thr ser cyt ala thr

(i) **Complete** the **DNA sequence** that would have acted as the template strand for the mRNA shown in **Image 5.1**. [1]

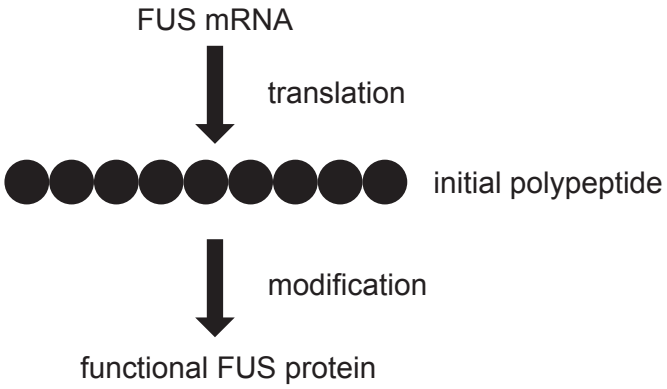
Coding strand	**ATG**	**CCG**	**GCA**	**CGG**	**ATT**	**CTG**
Template strand	TAC	GGC	CGT	GCC	TAA	GAC

(ii) State **one** feature of the genetic code demonstrated by the base sequences that code for **thr** (threonine) in **Image 5.1**. [1]

Degenerate: two codons (CCG and CUG) code for the same amino acid.

(b) The polypeptide produced from the mRNA molecule needs to undergo further modification before a functional protein is produced. This is summarised in **Image 5.2**.

Image 5.2



The functional FUS protein produced is globular consisting of a single polypeptide chain.

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During the translation of mRNA into the initial FUS polypeptide, energy is provided in the form of the triphosphonucleotide GTP which has a similar structure to ATP.

(i) I. Suggest the nitrogenous base found in GTP. [1]

Guanine.

II. Write an equation to show the exergonic reaction in which GTP would release energy. [1]

$GTP + H_2O \rightarrow GDP + Pi$

(ii) I. State where in a cell the initial FUS polypeptide chain would be modified to produce functional FUS protein. [1]

Golgi body (Golgi apparatus).

II. Name **two** types of molecule that could be added to the polypeptide chain to produce functional FUS protein. [1]

Molecule 1: carbohydrate

Molecule 2: lipid

(iii) I. State the highest level of protein structure that would be present in the functional protein. [1]

Tertiary structure.

II. Explain how this structure is maintained. [2]

Hydrogen bonds, ionic bonds and disulfide (covalent) bonds, plus hydrophobic interactions, form between the R (variable) groups of amino acids in the chain, holding the folded 3D shape.

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(c) In MND, a single base substitution in the FUS gene produces a polypeptide chain which is significantly shorter than normal.

Suggest how a single base change could result in such a shortened polypeptide chain. [2]

The substitution changes a codon (triplet) into a STOP codon, e.g. UAA, UAG or UGA in the mRNA.

So translation stops prematurely, giving a shorter polypeptide.

(d) The FUS gene contains 15 exons, from which several different versions of the FUS protein can be synthesised.

Suggest how this is possible and why it might provide evidence against the one gene-one polypeptide theory. [2]

Post-transcriptional modification: alternative splicing joins different combinations of the exons after the introns are removed, giving different mRNAs.

If the one gene-one polypeptide theory were true, only one polypeptide could be produced from a single gene.

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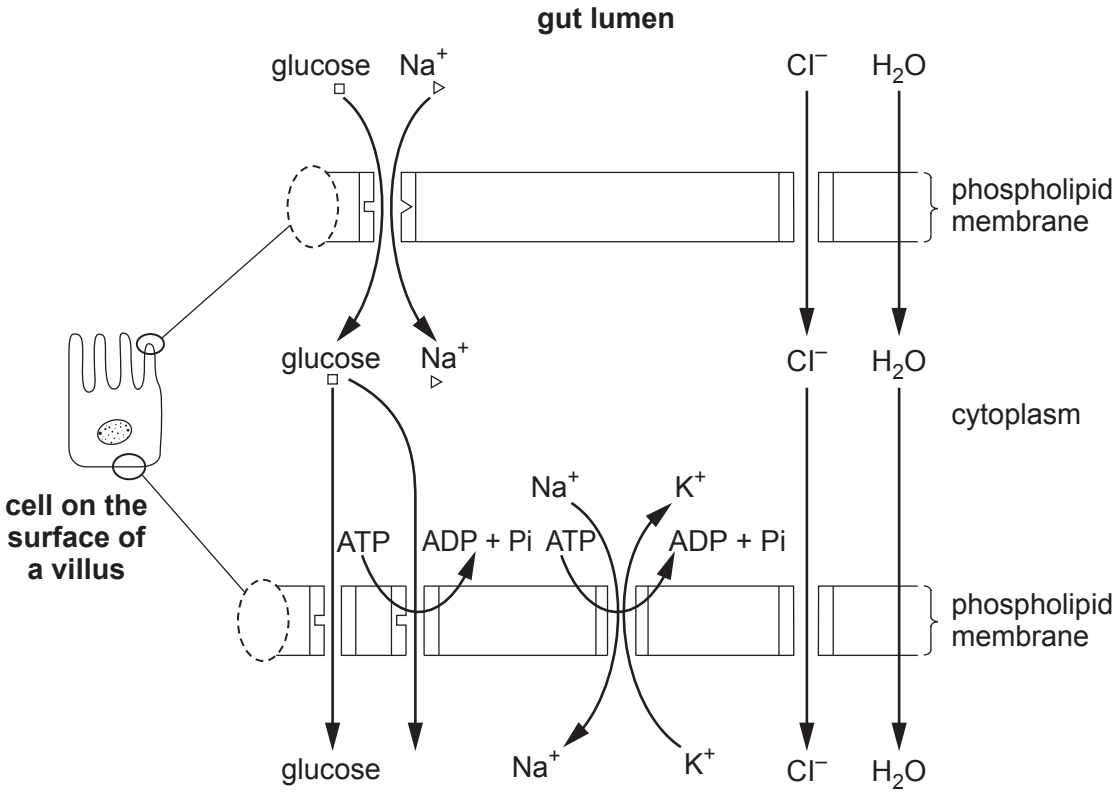
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6. **Image 6** shows how cells covering the surface of a villus in the small intestine transport some molecules from the gut lumen into tissue fluid.

Image 6



Identify the main transport methods shown in **Image 6** and state which molecules are transported by each method.

Describe the key features of each of these transport methods.

Explain how the efficiency of glucose transport into tissue fluid is increased by using a combination of transport methods. [9 QER]

Three main transport methods are shown: osmosis, facilitated diffusion and active transport, with co-transport of glucose and Na^+. Water (H_2O) moves by osmosis across both membranes. Cl^- moves by facilitated diffusion across both membranes, and glucose leaves the cell into the tissue fluid by facilitated diffusion. Glucose and Na^+ enter the cell from the gut lumen together by co-transport. Na^+ and K^+ are moved by active transport (the sodium-potassium

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pump) at the membrane next to the tissue fluid, Na^+ out of the cell and K^+ into it.

Osmosis: water moves from a region of higher water potential to a region of lower water potential through the partially permeable phospholipid membrane. It is passive, so it needs no ATP and relies on the kinetic energy of the molecules.

Facilitated diffusion (and the Na^+ moving in co-transport): particles move from a high concentration to a lower concentration, down their concentration gradient. It is passive, needs no ATP and relies on kinetic energy. It requires channel (or carrier) proteins because the particles are charged, ionic or polar (Cl^-, Na^+, glucose) and cannot pass through the hydrophobic fatty acid tails of the bilayer.

Active transport: particles can move from a low concentration to a higher concentration, against their concentration gradient. It requires ATP from respiration (ATP → ADP + Pi, as shown) and a carrier protein which changes shape; it is used for charged (ionic) particles such as Na^+ and K^+.

Efficiency of glucose transport: glucose is absorbed into the cytoplasm of the villus cell by co-transport with Na^+, so its absorption into the cell does not rely on a glucose concentration gradient. Glucose can therefore build up to a higher concentration in the cytoplasm than in the tissue fluid, which gives a greater concentration gradient between the cell and the tissue fluid, so glucose then leaves quickly by facilitated diffusion. Active transport of Na^+ out of the cell into the tissue fluid keeps the Na^+ concentration in the cytoplasm low, which increases the Na^+ concentration gradient between the gut lumen and the cell, so more Na^+ and therefore more glucose enter the cell. Active

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transport maintains these concentration gradients, ensuring continued absorption of glucose even when the glucose concentration in the gut lumen is lower than in the cell, so no glucose is lost in the faeces.

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