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

GCE AS

B400U10-1

S24-B400U10-1

MONDAY, 13 MAY 2024 – 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.** | **8** | |
| **2.** | **9** | |
| **3.** | **21** | |
| **4.** | **14** | |
| **5.** | **14** | |
| **6.** | **9** | |
| **Total** | **75** | |

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01

### 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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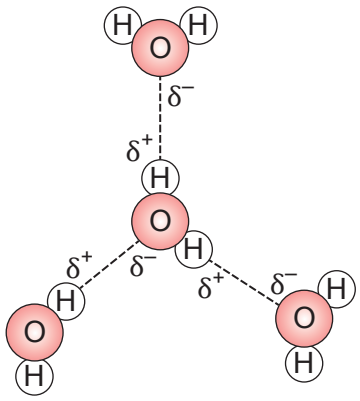
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Answer **all** questions.

**1.** Water is a polar molecule with a slightly uneven distribution of charge. This allows bonds to form between water molecules. **Image 1** shows the structure of water.

**Image 1**




(a) (i) State the name of the bond which forms between two water molecules. Explain why this bond forms. [2]

Hydrogen bonds. Water is polar (a dipole) with an uneven distribution of charge: the slightly negative (δ–) oxygen of one water molecule is attracted to a slightly positive (δ+) hydrogen of another molecule.

(ii) Transport of water in plants relies on some of the properties of water and the bonds between the water molecules.

State **two** properties of water which allow the transpiration stream to work in plants. [2]

Cohesion (between water molecules)

Adhesion (of water to the xylem walls)



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(iii) Water moving into the plants at the roots exerts root pressure.
Explain how root pressure contributes to the movement of water through the plant. [2]

Water moves by osmosis into (the base of) the xylem in the root, which pushes up the water already in the xylem, so water is forced up the stem.

(b) Complete the table to describe the advantages of the following properties of water to living organisms. [2]

| Property of water | Advantage to living organisms |
|---|---|
| Takes a large amount of energy to raise its temperature. | Body (cell cytoplasm) temperature remains stable as it changes slowly; aquatic environments have a stable temperature for the organisms living there. |
| Takes a large amount of energy for it to evaporate. | Sweating allows cooling (temperature control); a lot of heat is removed as sweat evaporates; aquatic habitats do not dry up easily. |

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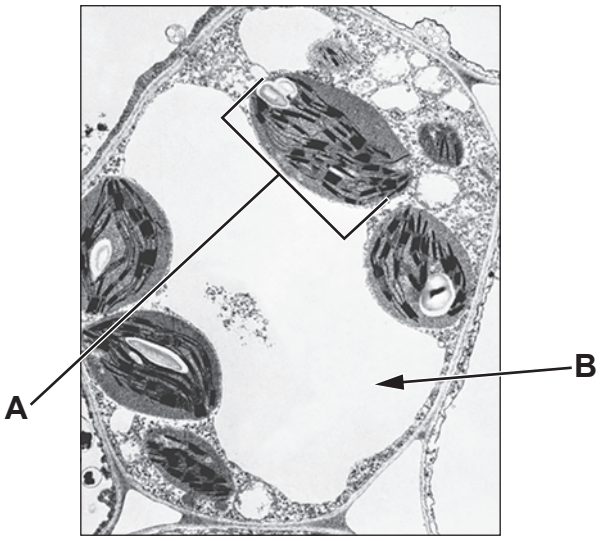


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**2.** **Image 2.1** shows an electron micrograph of a eukaryotic cell.

**Image 2.1**




(a) (i) Identify the structures labelled **A** and **B** in **Image 2.1**. [1]

**A** Chloroplast

**B** (Large permanent) vacuole

(ii) Using your answer to (a)(i), determine the Kingdom to which this cell belongs. [1]

Plantae (plant kingdom)

(iii) **Image 2.1** shows some internal features of structure **A**.
Suggest why these would not be visible if the cell had been viewed with a light microscope. [1]

The resolution of a light microscope is too low (and magnification not high enough) to see these internal membranes.

(b) Multicellular organisms have specialised cells which aggregate together into tissues, organs and then organ systems.

(i) State the difference between a tissue and an organ. [1]

A tissue is a group of similar cells (one type of cell) working together to perform a function, whereas an organ is a group of different tissues (many types of cell) working together to perform a function.



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(ii) Give an example of **one** tissue and **one** organ from a flowering plant. [2]

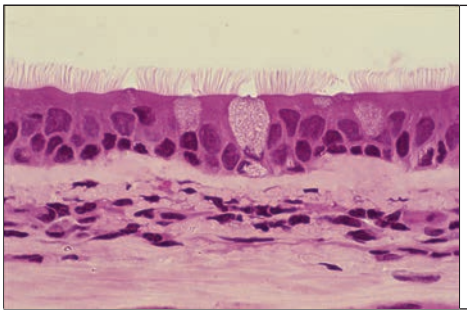
Tissue: Xylem

Organ: Leaf

(iii) **Images 2.2A**, **2.2B** and **2.2C** show photomicrographs of three different types of human tissue.

Identify the tissues shown in **Images 2.2A, 2.2B** and **2.2C** and give their function in the body. [3]

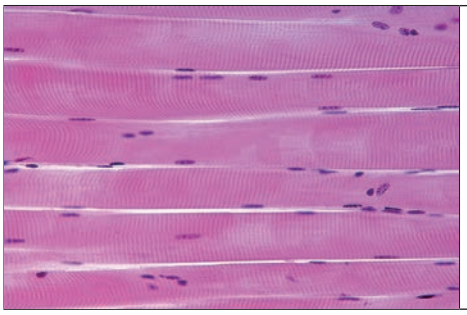
**Image 2.2A**



Tissue: Ciliated epithelium

Function: cilia waft (move) mucus along the airway (trachea)

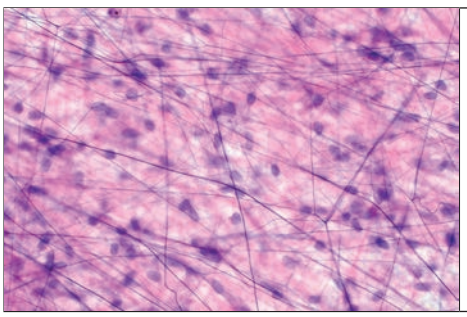
**Image 2.2B**



Tissue: Skeletal muscle

Function: contracts to cause movement (locomotion)

**Image 2.2C**



Tissue: Connective tissue

Function: connects, supports and separates other tissues

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**3.** Cellulose is a polysaccharide found in the cell wall of plants. Its structure makes the cell wall strong.

(a) (i) State which isomer of glucose is present in cellulose. [1]

β-glucose (beta glucose)

(ii) Describe how the arrangement of the glucose molecules gives strength to the cell wall. [3]

Chains of β-glucose are linked by β-1,4 glycosidic bonds, with alternate glucose molecules rotated by 180°, forming long straight (unbranched) chains. Parallel chains are cross linked by many hydrogen bonds, forming microfibrils (which group into fibres), giving high tensile strength.



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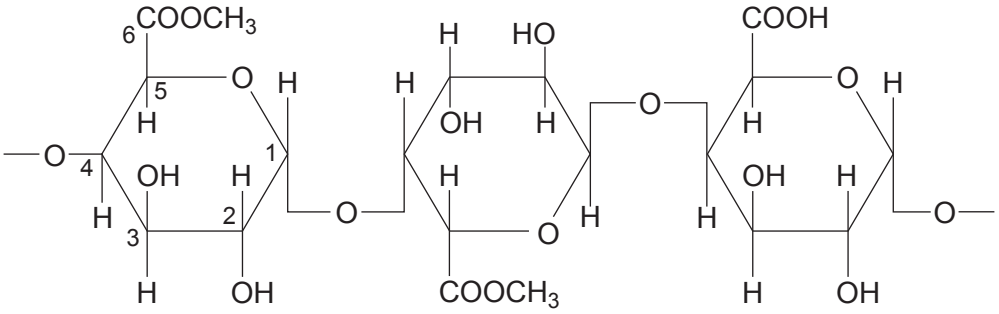


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Cellulose fibres in the plant cell wall are held together by another polysaccharide called pectin. **Image 3.1** shows part of the structure of pectin.

**Image 3.1**




(iii) Using **Image 3.1** and your knowledge of polysaccharides:

I. State the reaction involved in the formation of both cellulose and pectin. [1]

*Condensation reaction (forming glycosidic bonds)*

II. Give **one** similarity and **one** difference between the structure of cellulose and pectin. [2]

Similarity: *Both have alternate sugar monomers rotated by 180°, joined by (β) glycosidic links.*

Difference: *The carbon 6 group varies in pectin ($COOCH_3$ or $COOH$); in cellulose it is always $CH_2OH$.*

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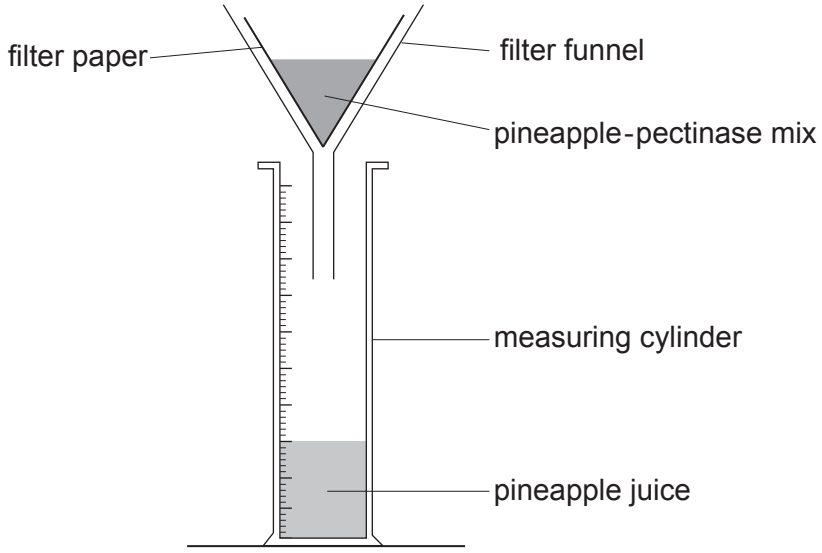
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(b) In the production of pineapple juice, pineapple pulp can be treated with pectinase, an enzyme which breaks down pectin in the cell wall. This releases more juice from the cells.

An investigation was carried out to show the effect of the concentration of pectinase on the breakdown of pectin. A brief method is given below. Some of the apparatus is shown in **Image 3.2**.

- Pineapple tissue was mashed to form a pulp.
- 5 $cm^3$ of 0.2% pectinase was added to the pulp and stirred for 10 seconds.
- The pineapple-pectinase mix was placed in a water bath at 25 °C for 1 hour.
- The mixture was then filtered and the volume of juice recorded.
- The experiment was repeated with a range of pectinase concentrations.

**Image 3.2**




(i) State the independent and dependent variables in this experiment. [1]

Independent variable: concentration of pectinase (%)

Dependent variable: volume of juice ($cm^3$)

(ii) Suggest **two** variables which were **not** controlled. [2]

pH of the pineapple-pectinase mix

mass (or ripeness) of the pineapple pulp

(iii) Explain **one** reason why the volume of juice collected may be lower than expected using the filtration method shown in **Image 3.2**. [1]

Some juice is absorbed by the filter paper (or pulp blocks the filter), so not all the juice reaches the cylinder.



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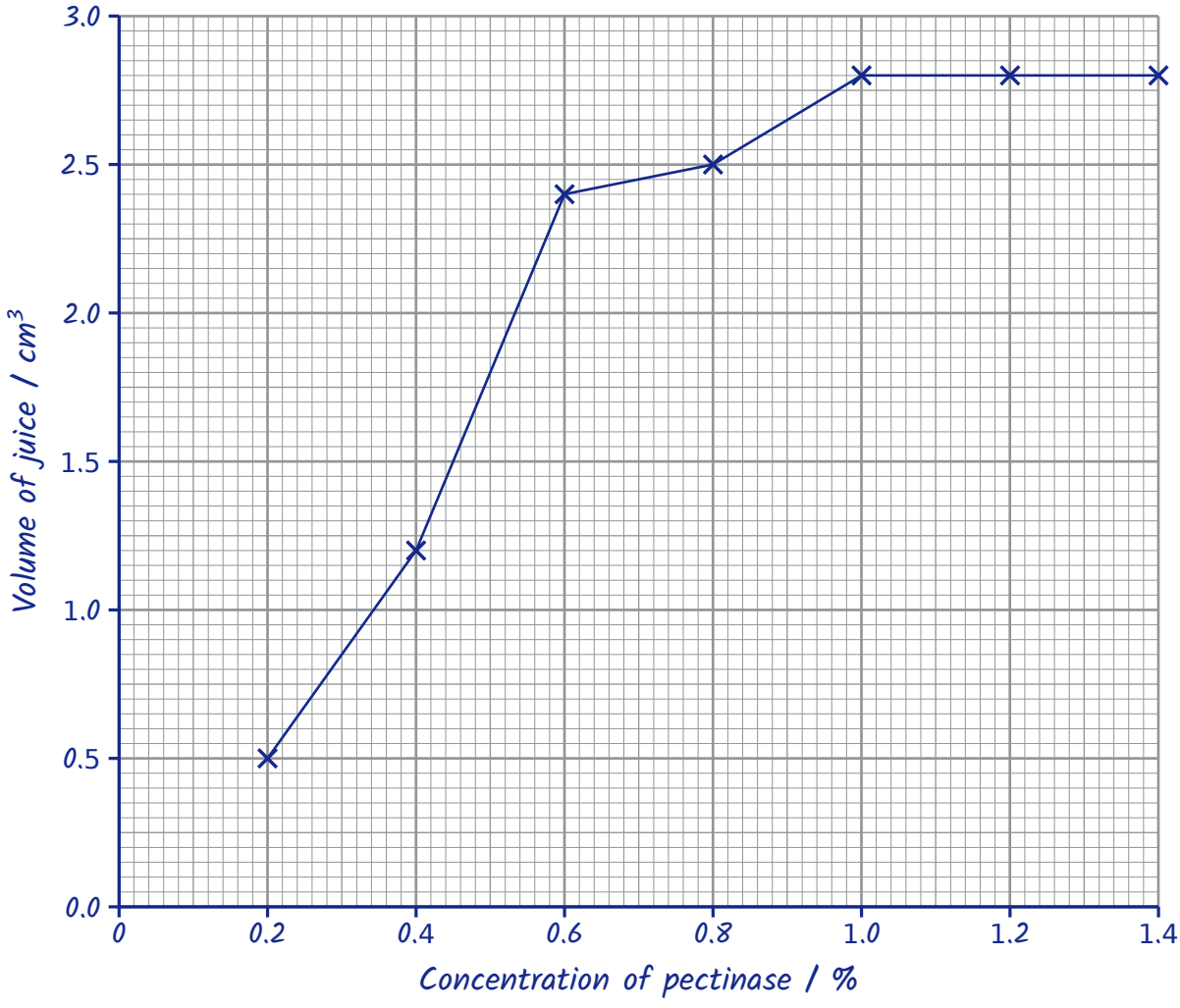
(c) **Table 3.3** shows the volume of juice recorded using a range of pectinase concentrations.

**Table 3.3**

| Concentration of pectinase / % | Volume of juice / $cm^3$ |
|---|---|
| 0.2 | 0.5 |
| 0.4 | 1.2 |
| 0.6 | 2.4 |
| 0.8 | 2.5 |
| 1.0 | 2.8 |
| 1.2 | 2.8 |
| 1.4 | 2.8 |

(i) Plot the data in **Table 3.3** on **Graph 3.4**. [4]

**Graph 3.4**




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(ii) Use **Graph 3.4** to describe and explain the effect of increasing the concentration of pectinase. [4]

As the concentration of pectinase increases from 0.2% to 0.6%, the volume of juice increases (0.5 to 2.4 $cm^3$). At low concentrations enzyme concentration is the limiting factor; more enzyme means more successful collisions and more enzyme-substrate complexes formed, so more pectin is broken down. Above 0.6% the increase in volume is not as great, and from 1.0% the volume stays the same (2.8 $cm^3$). At higher concentrations (0.6 to 1.0%) pectin (substrate) is the limiting factor, as all the substrate has been broken down.

(d) The pectinase and pineapple mixture was placed in a water bath at the optimum temperature for the enzyme. If incubation temperature was less than the optimum, the volume of juice extracted would have changed.

Suggest how the volume of juice extracted would have changed. Explain your answer. [2]

The volume of juice would be reduced. At a lower temperature the molecules have less kinetic energy, so there are fewer successful collisions and fewer enzyme-substrate complexes, so less pectin and fewer cell walls are broken down.

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**4.** (a) **Images 4.1A**, **4.1B** and **4.1C** show three types of nucleotides.

**Image 4.1A**

**ATP**

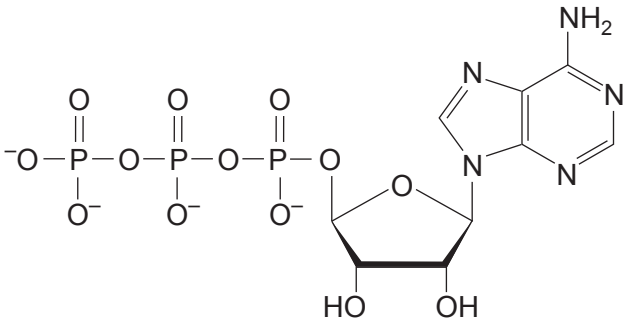


**Image 4.1B**

**NAD**

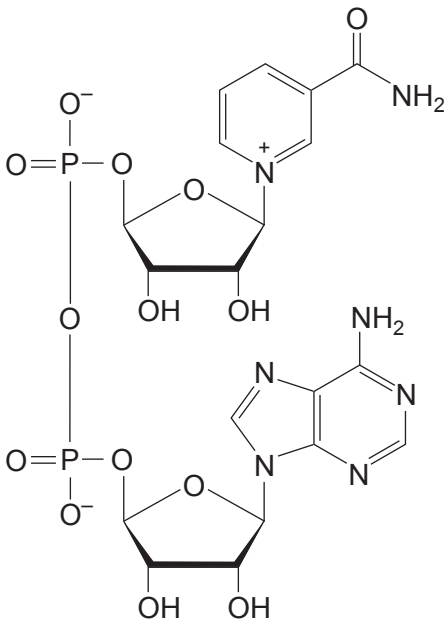
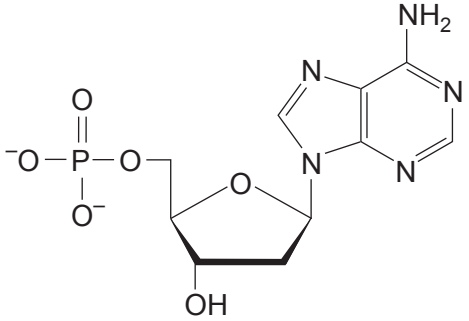


**Image 4.1C**

**DNA**



(i) Using **Images 4.1A**, **4.1B** and **4.1C**, state **one** similarity between all the molecules shown and **two** differences in structure between **ATP** and **NAD**. [3]

Similarity: *All contain a phosphate group, a pentose sugar and an (organic) nitrogenous base, adenine.*

Difference 1: *ATP has three phosphate groups but NAD has only two phosphate groups.*

Difference 2: *ATP has one sugar and one base (one nucleotide), but NAD has two sugars and two bases (two nucleotides joined).*



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(ii) Explain why ATP is a suitable 'energy currency' in all living organisms. [3]

ATP is hydrolysed to ADP and $P_i$ in a single reaction, so energy is released immediately where it is needed. Only one enzyme (ATPase) is needed. Energy is released in small amounts (30.6 kJ $mol^{-1}$), suitable for cell reactions, so little energy is wasted as heat.

**Question continued overleaf**



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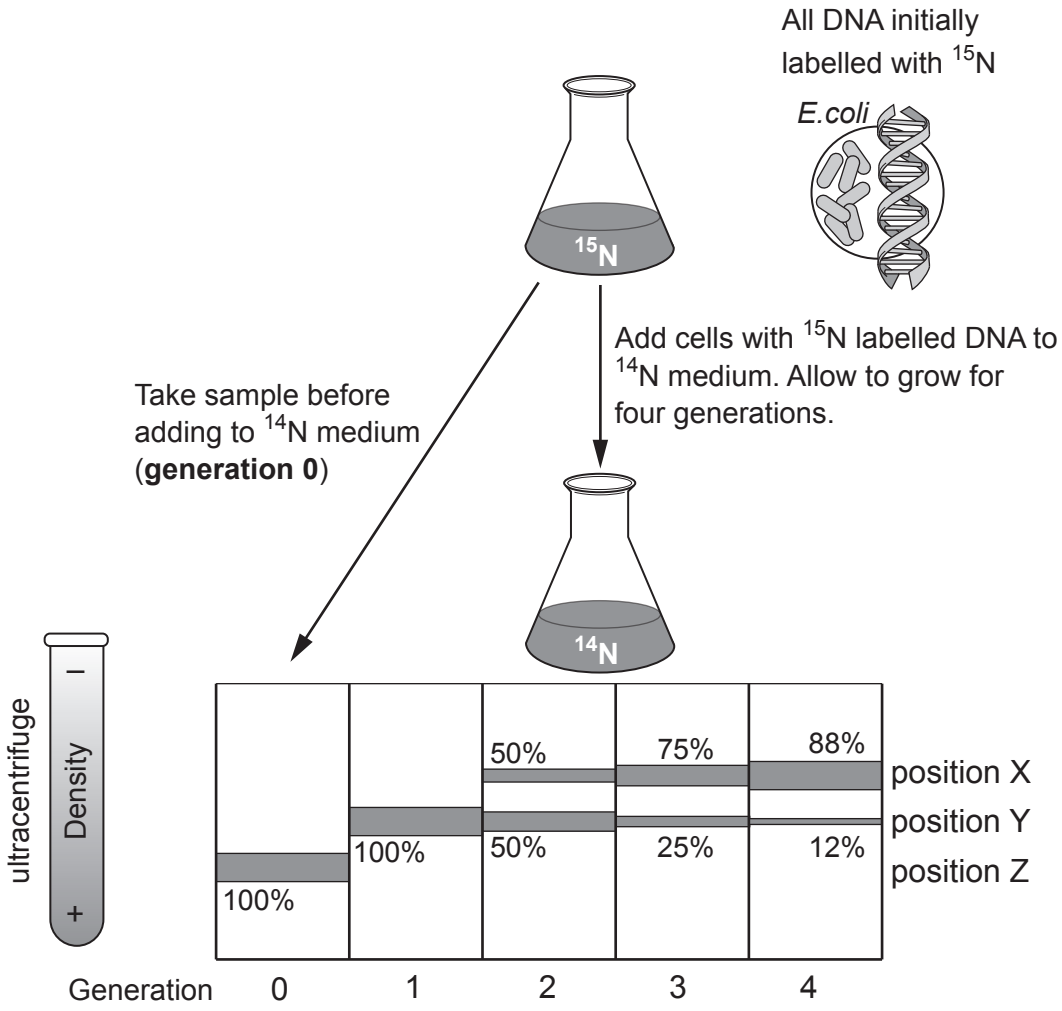
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(b) DNA is a very stable molecule which is passed on from generation to generation. Watson and Crick proposed that DNA must be replicated semi-conservatively. Experiments by Meselson and Stahl supported their theory. **Image 4.2** shows the Meselson and Stahl experiment and results. A sample of DNA was taken from each generation of cells and analysed using density gradient centrifugation.

The figures in **Image 4.2** show the percentage of DNA at each position after centrifugation.

**Image 4.2**




(i) The $^{14}N$ would be incorporated into the newly synthesised DNA.

State into which part of a DNA nucleotide the $^{14}N$ would be incorporated. [1]

The (organic) nitrogenous bases



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(ii) Suggest why the **generation 0** sample was taken before the $^{15}N$ labelled cells were added to the $^{14}N$ culture medium. [1]

To show the density (maximum density) of DNA containing only $^{15}N$, so it could be compared with the other generations.

(iii) Use your own knowledge and the information in **Image 4.2** to explain how the results for the following generations support the theory of semi-conservative replication.

I. **Generation 1** [2]

Only $^{14}N$ (light) nucleotides are available for replication, so each new DNA molecule keeps one original $^{15}N$ strand and one newly formed $^{14}N$ strand: 100% hybrid $^{15}N^{14}N$ DNA at the intermediate position Y.

II. **Generations 2–3** [3]

Generation 2 has 50% at each density: 50% $^{14}N^{14}N$ DNA (position X) and 50% $^{15}N^{14}N$ DNA (position Y), because both the $^{15}N$ strand and the $^{14}N$ strand of each hybrid molecule were used as templates for new DNA. Generation 3 has 75% $^{14}N^{14}N$ DNA (wider band at X) because more $^{14}N$ strands are used as templates, while the original $^{15}N$ strands stay in 25% hybrid DNA.

(iv) Suggest why the percentage of DNA found at position **Y** in **generation 1** has reduced from 100% to 12% by **generation 4**. [1]

No more $^{15}N$ is available, so the number of $^{14}N^{14}N$ DNA molecules increases and the proportion of $^{15}N$ DNA falls.

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**5.** (a) An investigation was carried out on the effect of surface area on osmosis. A brief method is shown below:

- Four cylinders were taken from the cortex of a carrot using a 15 mm diameter cork borer and each cut to 40 mm in length.
- The initial mass of each cylinder was recorded.
- Each cylinder was cut into a different number of equal length pieces to increase the surface area.
- The cylinder pieces were placed in a sucrose solution of 0.1 M and left for 24 hours.
- The final mass of the cylinder pieces was recorded.

The volumes and surface areas for each cylinder are shown in **Table 5.1**.

**Table 5.1**

| Cylinder | Number of pieces | Radius / mm | Length of each piece / mm | Total surface area / $mm^2$ | Volume / $mm^3$ | Surface area: Volume ratio |
|---|---|---|---|---|---|---|
| **A** | 1 | 7.5 | 40 | 2237 | 7068 | 0.32 : 1 |
| **B** | 2 | 7.5 | 20 | 2591 | 7068 | 0.37 : 1 |
| **C** | 4 | 7.5 | 10 | 3297 | 7068 | 0.47 : 1 |
| **D** | 8 | 7.5 | 5 | 4710 | 7068 | 0.67 :1 |

(i) Complete **Table 5.1** for cylinder **D** by:

I. Calculating the total surface area. [2]

Use the formula $n(2\pi rh + 2\ \pi r^2)$
Where $n$ = number of pieces
$r$ = radius
$h$ = length of each piece

Use $\pi = 3.14$

Space for working

$SA = 8 \times (2 \times 3.14 \times 7.5 \times 5 + 2 \times 3.14 \times 7.5^2)$

$= 8 \times (235.5 + 353.25)$

$= 8 \times 588.75 = 4710\ mm^2$

II. Calculating the surface area to volume ratio. [1]

Space for working

$SA : V = 4710 \div 7068 = 0.666 = 0.67 : 1$



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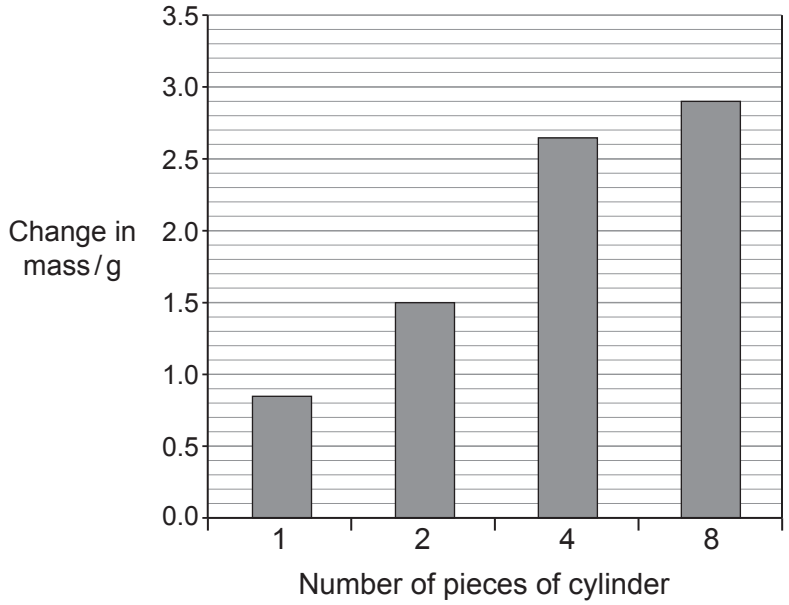


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The results of the experiment are shown in **Graph 5.2**.

**Graph 5.2**




(ii) Use your knowledge of osmosis, **Table 5.1** and **Graph 5.2**.

Describe and explain how the number of pieces of cylinder affects the change in mass of the carrot. [5]

The higher the number of pieces, the greater the change in mass: from about 0.85 g for 1 piece to about 2.9 g for 8 pieces. There is less of an increase (levelling off) at higher numbers of pieces, from 4 to 8 pieces. The greater the number of pieces, the greater the surface area (SA:V ratio increases from 0.32 : 1 to 0.67 : 1), so there is more exposed cell membrane for osmosis to take place over. The external 0.1 M sucrose solution had a higher water potential than the carrot cells, so water moved into the cylinders by osmosis, down the water potential gradient. The mass increased due to the increased water in the cells, and with a larger surface area more water entered in the 24 hours.



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(iii) When the number of pieces was increased to 16, the change in mass remained the same as for 8 pieces. Suggest an explanation for this. [1]

All the cells are already fully turgid (cells have reached equilibrium), so no more water can enter.

(b) (i) The steps below show part of a method that could be used to find the water potential of the carrot tissue.

- Prepare six cylinders of carrot, each measuring 40 mm in length.
- Record the initial mass of each cylinder.
- Place one cylinder into one of a range of sucrose solutions (0.0 M, 0.2 M, 0.4 M, 0.6 M, 0.8 M or 1.0 M).
- Leave for 24 hours.
- Carefully dry each cylinder and record the final mass of each cylinder.

Complete the method above by stating the final steps which would be required to find the water potential of the carrot tissue. [2]

Calculate the percentage change in mass for each cylinder and plot a graph of % change in mass against sucrose concentration; read off the concentration where there is no change in mass, then use a solute potential table to convert it to the water potential.

(ii) Older carrots convert sugars to starch.

Suggest what would happen to the water potential of carrot tissue if older carrots were used in the method in (b)(i). Explain your answer. [3]

The water potential of the carrot tissue would be higher (less negative). Starch is insoluble so it has no osmotic effect, and there is less sugar dissolved in the cells, so the solute potential increases (becomes less negative).

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**6.** Cells of the airway in humans secrete mucus. The thickness of this mucus is regulated by the movement of chloride ions through an intrinsic membrane protein called CFTR. This protein is coded for by the CFTR gene.

Cystic fibrosis is a condition where the movement of chloride ions is reduced, resulting in thicker mucus. The condition can be caused by mutations in the CFTR gene. One mutation causes the deletion of a single amino acid from the protein.

Use your knowledge of the genetic code and protein synthesis to explain how a mutation in the CFTR gene could cause a deletion of an amino acid.

Describe how this deletion could affect the structure of the CFTR protein.

Suggest how this deletion could affect the function of the CFTR protein. [9 QER]

A gene is a sequence of DNA bases that codes for a polypeptide. The genetic code is a triplet code: each sequence of three bases (a codon) codes for one amino acid. If a mutation deletes three bases (one triplet) from the CFTR gene, the mRNA transcribed from the gene will have no codon (no mRNA code) for that amino acid. During translation at the ribosome there is no codon-anticodon complex formed for that particular amino acid, so no tRNA brings it and the amino acid is missing from the primary sequence of the polypeptide chain. As whole triplets are lost, the reading frame is not shifted, so the rest of the amino acids are unchanged.

This gives the CFTR protein a different primary structure: a different, shorter amino acid sequence. This can change the secondary structure, as hydrogen bonds form in different places, so the α-helices and β-pleated sheets may be different. The tertiary structure is changed because the R groups are in different positions, so hydrogen bonds, ionic bonds and disulfide bridges form in different places. As a result the protein folds differently and its 3D shape is changed.

CFTR is an intrinsic transport (channel) protein. If its 3D shape is changed, the channel is no longer the correct shape or complementary to chloride ions, so $Cl^-$ does not fit through and is not transported (or less is transported) across the membrane. The hydrophobic and hydrophilic regions of the protein



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may no longer be in the correct position, so the protein may no longer span the phospholipid bilayer as an intrinsic protein. With less chloride ion movement, less water follows by osmosis, so the mucus viscosity is not regulated and the mucus becomes thicker, as in cystic fibrosis.



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**END OF PAPER**

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