OCR
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Wednesday 18 June 2025 – Morning

A Level Biology A

H420/03 Unified biology

Time allowed: 1 hour 30 minutes

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

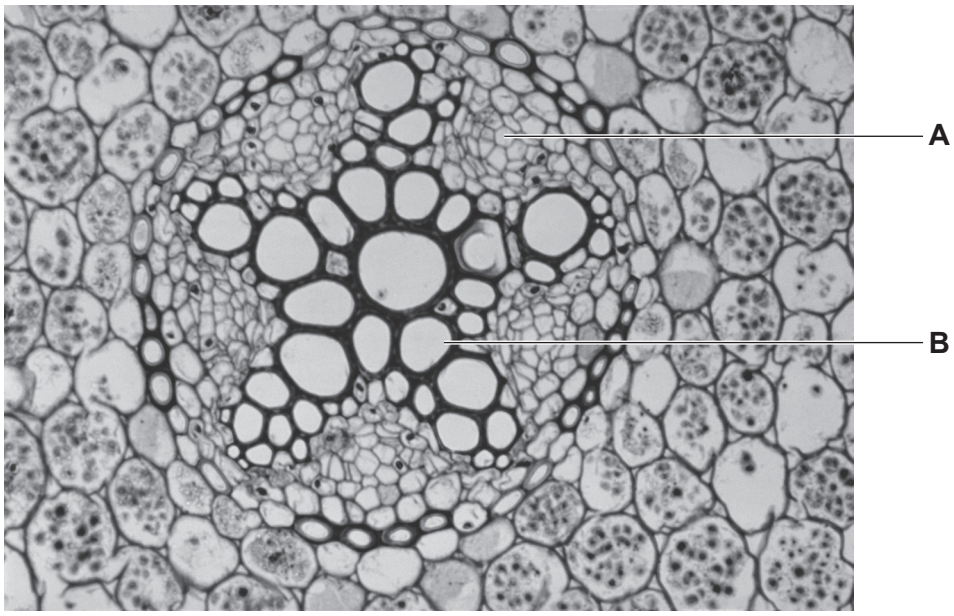
INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **28** pages.

ADVICE
- Read each question carefully before you start your answer.

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1 The roots of plants contain a variety of cells and tissues.

(a) The photomicrograph shows a transverse section through the root of a herbaceous dicotyledonous plant.



Name the cells labelled **A** and **B** in the photomicrograph.

A .....

B .....

[2]

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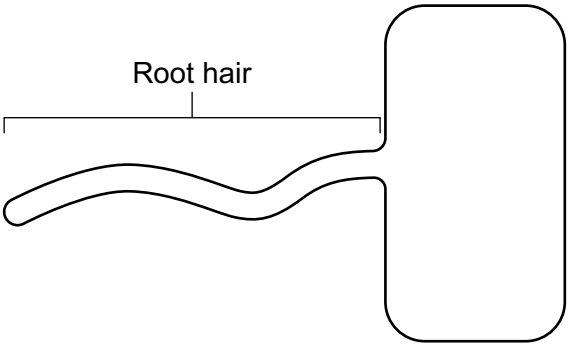
(b) The outer surface of a root is made up of root epidermal cells.

A root hair cell is a type of root epidermal cell that has a hair-like extension called a root hair.

A typical root epidermal cell has a surface area to volume ratio (SA : V) of 0.3 : 1.

A root hair cell has a higher SA : V than a typical root epidermal cell.

The diagram shows a root hair cell. The diagram is not to scale.



The root hair has:
- a diameter of 10 μm
- a length of 800 μm.

(i) Calculate the SA : V of the root hair.

Assume the root hair is cylindrical.

Use the equations:

Surface area of cylinder = $2\pi r(r + l)$

Volume of cylinder = $\pi r^2 l$

SA : V of root hair = ... **[3]**

(ii) State how a high SA : V helps a root hair cell perform its function.

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..... **[1]**

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(c) Carbohydrates produced in palisade cells are transported in phloem to sinks, such as roots.

Describe how carbohydrates move from palisade cells into companion cells in phloem.

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..... **[3]**

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2 Adrenaline is a hormone that increases heart rate when it binds to receptors on heart cells.

Beta blockers are drugs that bind to adrenaline receptors on heart cells.

Beta blockers are used to treat tachycardia (fast heart rate) and high blood pressure. They reduce the risk of a heart attack or stroke, which are two examples of cardiovascular diseases.

(a) The conversion of ATP to cyclic AMP (cAMP) in a heart cell is prevented when beta blockers bind to adrenaline receptors on the cell surface membrane.

(i) Describe **one** difference between the structure of ATP and the structure of ADP.

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..... **[1]**

(ii) Suggest how the binding of beta blockers to adrenaline receptors prevents the conversion of ATP to cAMP.

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..... **[2]**

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(b) A scientist studied the health outcomes of people with high blood pressure that were treated with either:

- a new beta blocker treatment

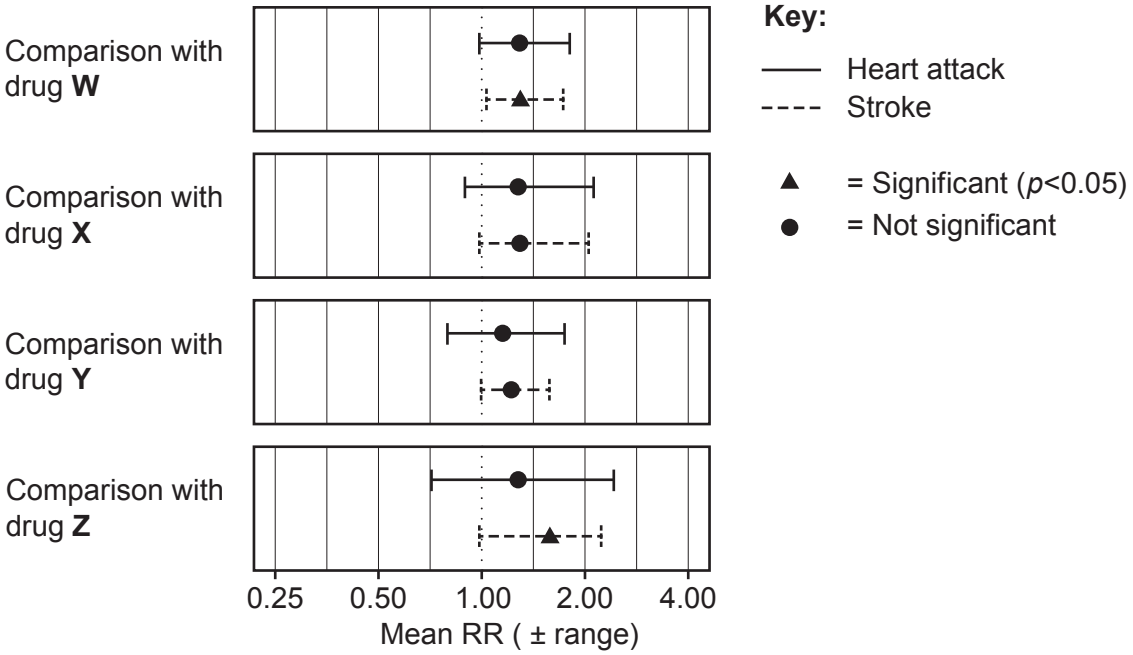
or

- one of four established treatments (drug **W**, **X**, **Y** or **Z**).

The scientist assessed the relative risk of a person in the study having a heart attack or having a stroke.

- A relative risk (RR) value of 1 means that the risk for people taking beta blockers is the same as the risk for people taking another drug.
- RR <1 means that there is a lower risk for people taking beta blockers.
- RR >1 means that there is a higher risk for people taking beta blockers.

The graph shows the results of the scientist's analysis. The error bars show ± 2 standard deviations.



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A student looked at the results and concluded:

'the beta blocker does not seem to be an effective treatment for cardiovascular diseases'.

Evaluate whether the evidence in the graph supports this conclusion.

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..... **[4]**

(c) Heart rate is lowered when the heart receives stimulation from the vagus nerve.

Explain why the vagus nerve is considered part of the peripheral nervous system **and** part of the autonomic nervous system.

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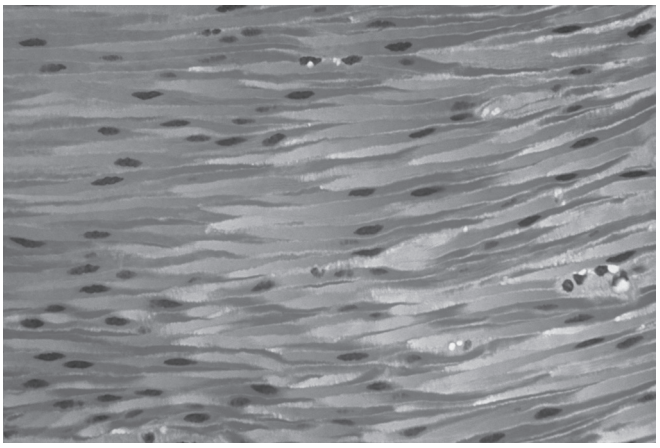
..... **[2]**

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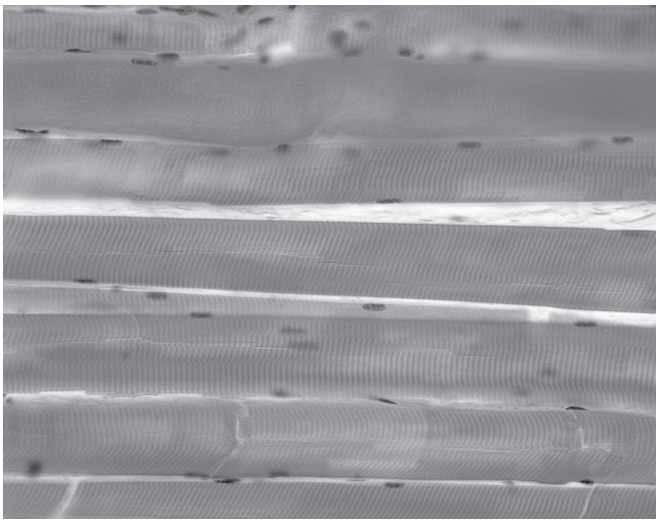
3

(a)* The three photomicrographs, **D**, **E** and **F**, show three different types of muscle tissue.

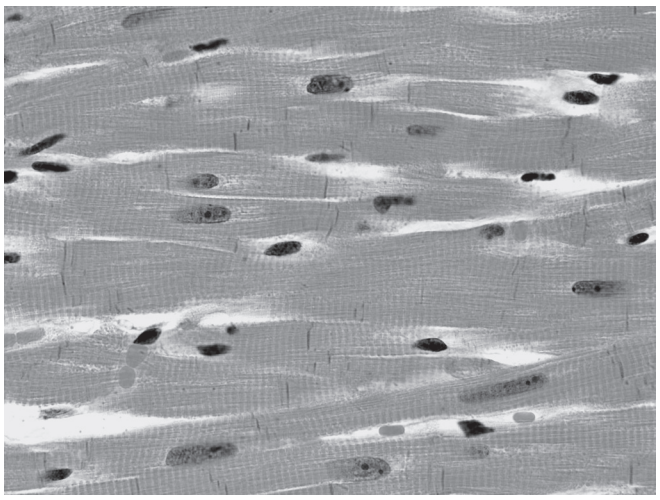
D



E



F



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State which photomicrograph shows cardiac muscle, which shows involuntary (smooth) muscle and which shows skeletal muscle.

Describe the evidence that supports your identification of each type of muscle tissue.

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..... **[6]**

Extra answer space if required.

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(b) The table lists events that occur during muscle contraction. Each event is represented by a letter.

Letter	Event
H	ATP binds to myosin, which causes myosin to detach from actin.
I	Troponin changes shape.
J	Myosin binds to actin.
K	ADP is released from myosin.
L	Hydrolysis of ATP causes the myosin head to regain its original position.
M	Ca^{2+} ions bind to troponin.
N	Tropomyosin moves position.

Give the sequence of letters that shows the correct order of events during muscle contraction.

The first letter has been done for you.

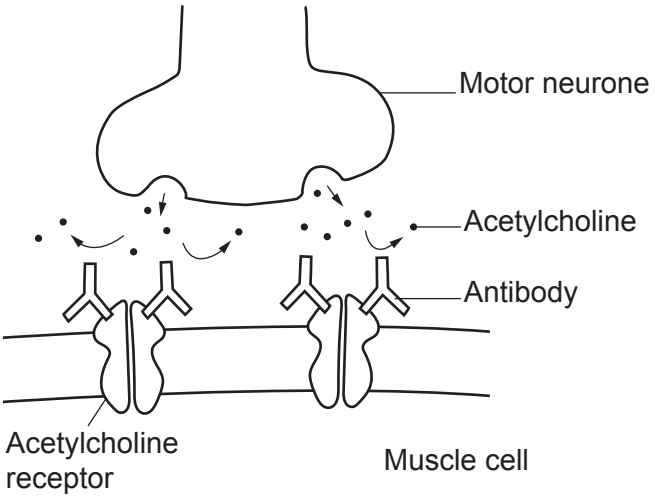
M .... **[3]**

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(c) Myasthenia gravis (MG) is a disease that causes muscle weakness.

In MG, antibodies bind to acetylcholine receptors in neuromuscular junctions which prevents acetylcholine from binding to the receptors.

The diagram shows this process.



(i) State the name given to diseases such as MG.

..... **[1]**

(ii) Explain how the binding of antibodies to acetylcholine receptors in the neuromuscular junction reduces the rate at which Ca^{2+} ions bind to troponin.

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..... **[2]**

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4 RNA and DNA are polynucleotides.

(a) Two types of RNA are messenger RNA and transfer RNA.

The table shows some properties of these two types of RNA.

Place ticks (✓) in the correct boxes to indicate which properties are true for each type of RNA.

Property	Messenger RNA	Transfer RNA
Anticodons are present.		
The nucleotide base sequence codes for a polypeptide.		
Uracil is bonded to adenine by hydrogen bonds within the molecule.		

[2]

(b) Outline how gene expression is regulated within cells at the post-transcriptional level.

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..... **[2]**

(c) A student writes this method for extracting DNA from animal cells:

1. Grind the sample of cells using a mortar and pestle.
2. Mix the sample with detergent.
3. Add ethanol to precipitate the DNA from the solution.
4. Spool the DNA onto a glass rod.

(i) Another student suggests that step 1, grinding the sample of cells, is unnecessary.

Explain why step 1 is unnecessary.

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..... **[2]**

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(ii) State **one other** step that the student should include in the method **and** explain why this step is necessary.

Step .....

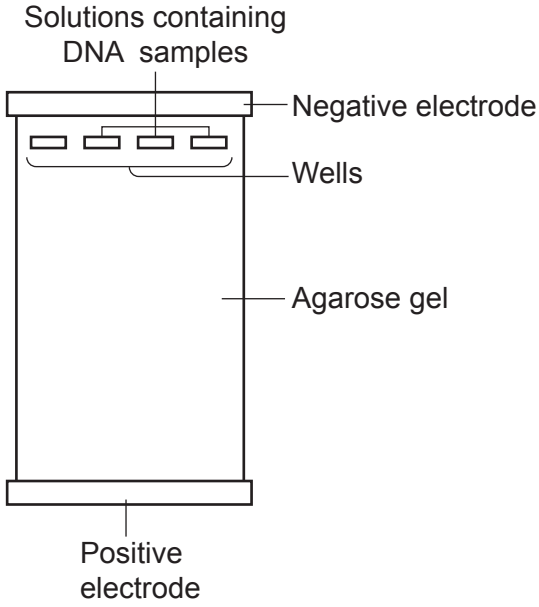
Explanation .....

.....

[1]

(d) Electrophoresis is used to separate fragments of DNA so that the separated DNA fragments can be compared and analysed.

(i) The diagram shows an electrophoresis box. Solutions of DNA samples have been added to three of the wells in the box.



State **two other** solutions that should be added to the box before performing electrophoresis **and** explain the purpose of each solution.

Solution .....

Explanation .....

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Solution .....

Explanation .....

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[4]

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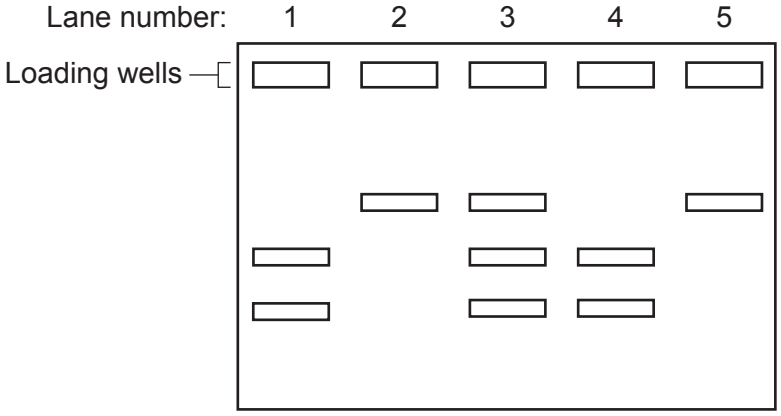
(ii) Electrophoresis can be used to detect disease-causing alleles, such as the mutant *HBB* allele that causes sickle cell disease.

Restriction enzymes are used to produce fragments of *HBB* alleles for analysis by electrophoresis.

These restriction enzymes:

- produce one fragment when the sickle cell *HBB* allele is present
- produce two smaller fragments when the normal *HBB* allele is present.

The diagram shows the results of electrophoresis of DNA samples from five people. It only shows DNA fragments from the *HBB* gene.



State the lane numbers that indicate:

- a genotype that is homozygous for the sickle cell *HBB* allele
- a genotype that is homozygous for the normal *HBB* allele
- a heterozygous genotype for the *HBB* gene.

Homozygous sickle cell .....

Homozygous normal .....

Heterozygous .....

[2]

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(e) Bacterial cells can be used for genetic engineering.

A donor gene is placed into a plasmid, which is taken up by a bacterial cell.

This process is inefficient. Not all plasmids form recombinant DNA with the donor gene, and only a small percentage of bacterial cells take up plasmids.

(i) A scientist estimates that 40% of their plasmids join to the donor gene to form recombinant DNA.

One in 2500 bacterial cells takes up a plasmid to form a transformed bacterial cell.

The scientist uses 1×10^9 bacterial cells.

Calculate the number of cells that take up a plasmid containing the donor gene.

Number of bacterial cells = ... **[2]**

(ii) The percentage of plasmids that are taken up by bacterial cells is known as the transformation efficiency.

Suggest **one** factor that scientists could change to improve transformation efficiency.

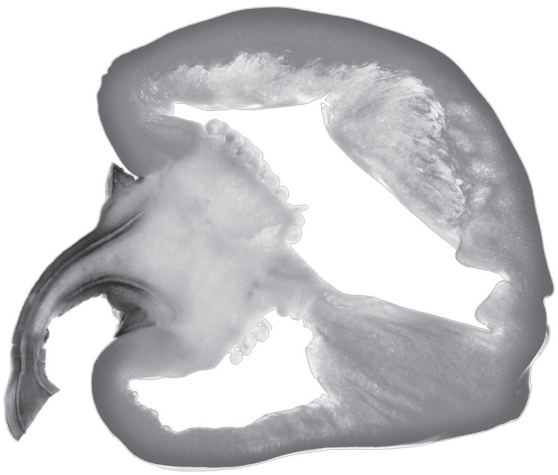
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..... **[1]**

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5 A student investigates water potential in the cells of a bell pepper, *Capsicum annuum*.

A slice of bell pepper is shown in the image.



The student:

- prepares several concentrations of sucrose solution
- cuts pieces of pepper and records the mass of each piece
- places pieces of pepper in each sucrose solution
- removes the pieces after 30 minutes and dries them
- records the mass of each piece.

(a) The student makes sucrose solutions of different concentrations by diluting a stock solution.

State a piece of equipment, with a higher resolution than a measuring cylinder, that the student should use to transfer solutions during the dilution procedure.

..... **[1]**

(b) The student controls temperature and the time that the pepper pieces are in the sucrose solution.

State **one** other variable that the student should control during the experiment.

..... **[1]**

(c) The student calculates the change in mass of each piece of pepper during the experiment and converts these values to percentage change in mass.

Explain why the student converts the results to percentage change in mass.

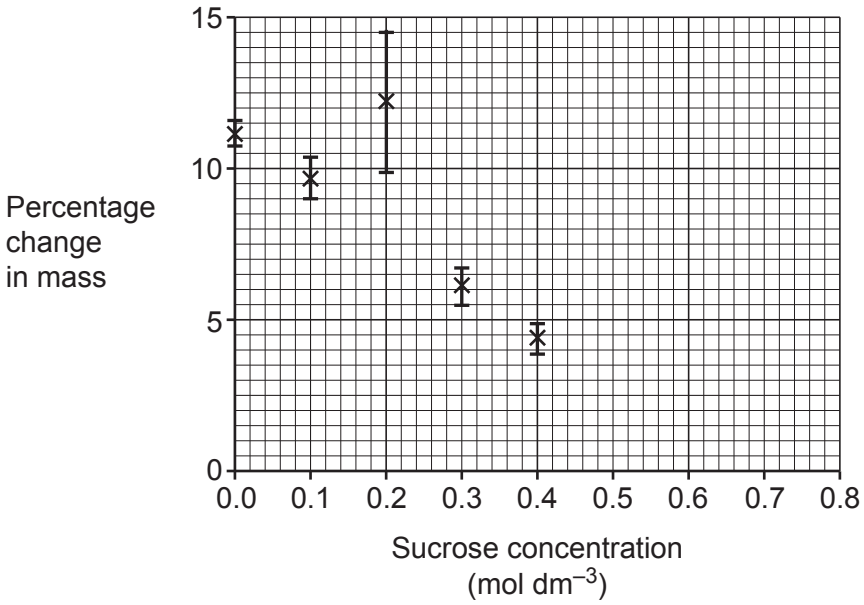
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..... **[1]**

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(d) The graph shows the results of the experiment.



Use the graph to estimate the concentration of sucrose solution that has the same water potential as the pepper tissue.

Concentration of sucrose solution = ... mol dm^{-3} **[2]**

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6 β-thalassemia is an inherited blood disorder in which the β-globin chain of haemoglobin is changed or absent in a person's red blood cells.

Many different DNA mutations in the β-globin gene can cause β-thalassemia, including these two mutations:

mutation 1: **C G G ⟶ C T G**

mutation 2: **G T C ⟶ A T C**

Each mutation occurs in a triplet in the template strand of DNA.

The transcribed mRNA is complementary to the template strand.

(a)

(i) The diagram on the opposite page is a representation of the genetic code. It shows the amino acid encoded by each mRNA codon.

The letters in the centre of the diagram represent the first base in each codon.

State the amino acids that are encoded by the original triplet and the mutated triplet in mutation 1.

Original amino acid .....

New amino acid .....

[1]

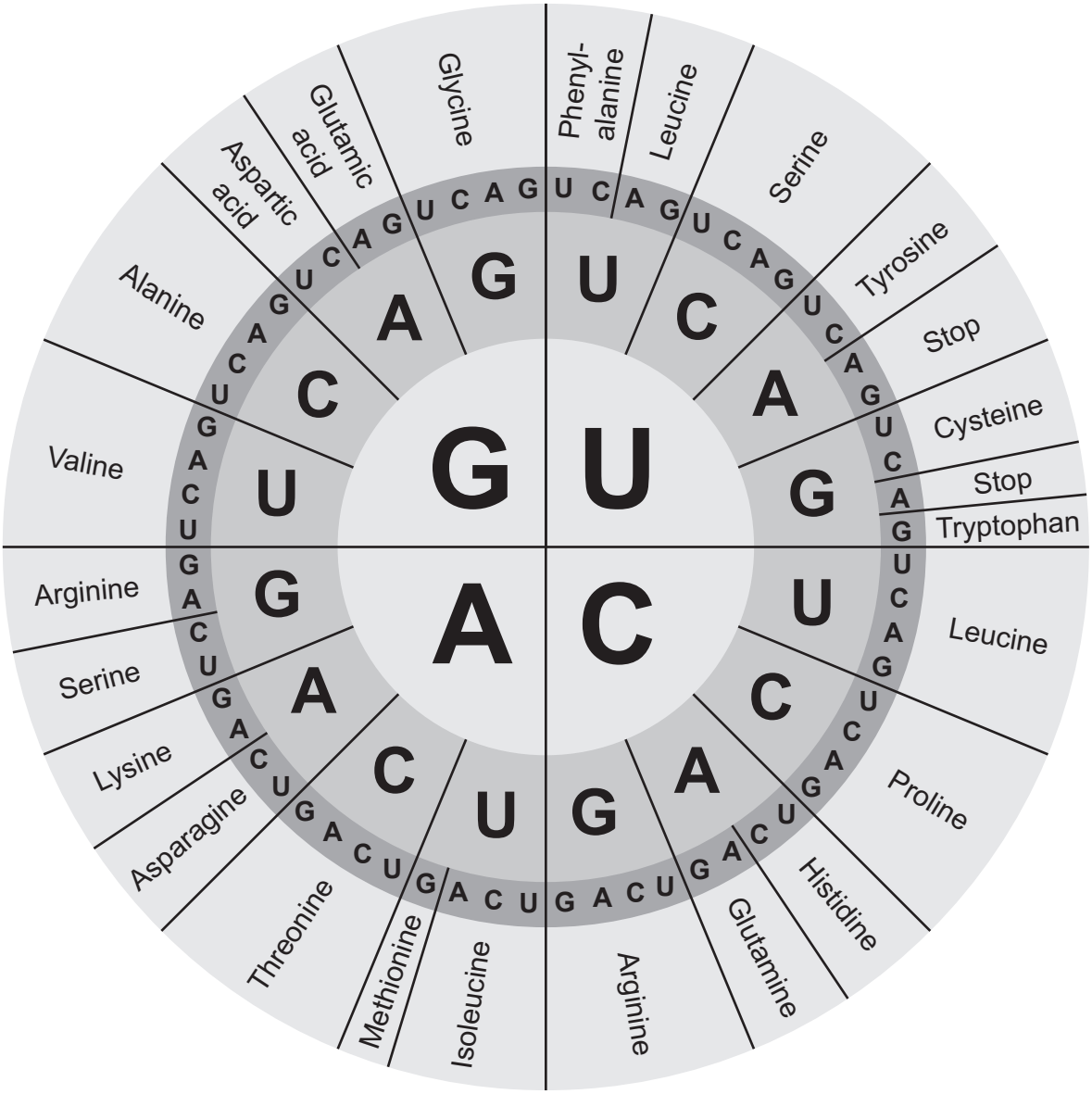
(ii) State **and** explain the effect of mutation 2 on the structure of the β-chain of haemoglobin.

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..... **[1]**

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Glycine
Glutamic acid
Aspartic acid
Alanine
Valine
Arginine
Serine
Lysine
Asparagine
Threonine
Methionine
Isoleucine
Phenyl-alanine
Leucine
Serine
Tyrosine
Stop
Cysteine
Stop
Tryptophan
Leucine
Proline
Histidine
Glutamine
Arginine
G
U
A
C
U C A G

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(b)* In 2023, a gene editing treatment for β-thalassemia was approved for use in the UK.

Gene editing is a form of gene therapy.

Standard gene therapy:
- uses a vector to deliver a functional, normal allele to cells in a person's body
- does not remove the faulty, disease-causing allele from the person's cells.

Gene editing:
- can correct the faulty, disease-causing allele so that only the functional, normal allele is present at that locus
- can be performed on stem cells that have been removed from a person's body; the stem cells are then transferred back into that person.

Discuss the advantages of gene editing compared to standard gene therapy **and** discuss the ethical issues shared by both forms of gene therapy.

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..... **[6]**

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Extra answer space if required.

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7 Pathogens are transmitted to animals and plants by a variety of methods.

(a) A group of scientists collected and analysed data about climate change and the number of cases of diseases transmitted by animal vectors.

The scientists wanted to know whether the number of cases of each disease had increased as a result of climate change.

They found that the number of cases had increased for 103 different animal vector-transmitted diseases.

The scientists concluded that climate change has increased the transmission of pathogens by animal vectors.

(i) Suggest **one** additional piece of information that is needed to assess the validity of the scientists' conclusion.

.....

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..... **[1]**

(ii) Suggest why climate change might result in more cases of diseases caused by animal vector-transmitted pathogens.

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..... **[1]**

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(b) Neutrophils are white blood cells that contribute to the immune response against infection.

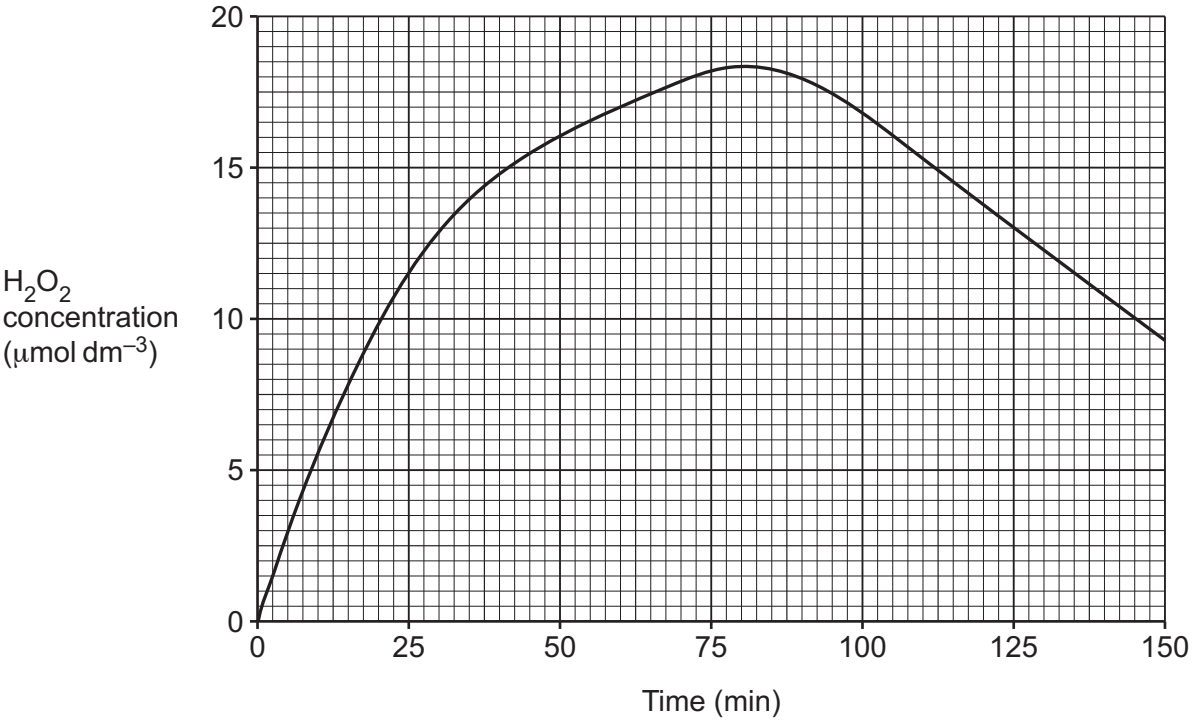
Neutrophils produce oxidative bursts as part of their response to infection.

An oxidative burst is the rapid production of highly reactive particles, including hydrogen peroxide (H_2O_2), inside the cell.

(i) State the location of the stem cells that differentiate into neutrophils.

..... **[1]**

(ii) The graph shows the change in hydrogen peroxide concentration in a neutrophil during an oxidative burst.



Use the graph to calculate the **initial rate** of increase of H_2O_2 concentration in the neutrophil during an oxidative burst.

Rate = ... Units ..... **[3]**

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(iii) Suggest how an oxidative burst helps neutrophils to perform their function.

.....

..... **[1]**

(iv) Antibodies can bind to receptors on the cell surface membrane of a neutrophil.

The binding of an antibody to a receptor causes the neutrophil to engulf the pathogen that is bound to the antibody.

State the name given to antibodies that act in this way.

..... **[1]**

(c) Plants lack immune cells, but they have other defences against pathogenic infection.

The sentences describe one form of plant defence against pathogens.

Complete the sentences using the most appropriate word or phrase.

When a pathogen is detected in plant tissue, a plant increases the production of a polysaccharide called ..... . This polysaccharide is deposited in channels called ....., which pass through cell walls. This deposition stops the pathogen moving between cells. The polysaccharide is also deposited in the small gaps between sieve tube elements. These gaps are known as ..... . This deposition stops the pathogen moving between different regions of the plant.

[3]

END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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