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Candidate number

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Surname

StemUp Model Solution

Forename(s)

Candidate signature

I declare this is my own work.

AS BIOLOGY

Paper 1

Monday 12 May 2025

Morning

Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for the questions are shown in brackets.
- The maximum mark for this paper is 75.

For Examiner's Use

Question	Mark
1	
2	
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TOTAL	

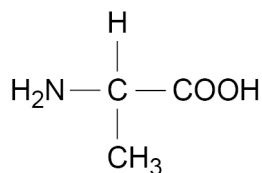


J U N 2 5 7 4 0 1 1 0 1

Answer **all** questions in the spaces provided.

0 1 . 1 **Figure 1** shows the structure of the amino acid alanine.

Figure 1



Name the NH_2 and COOH groups in the amino acid.

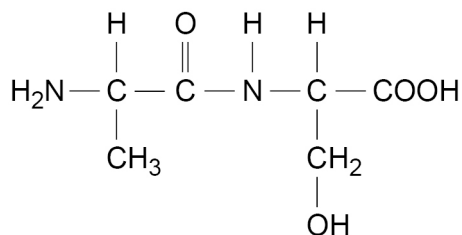
[1 mark]

NH_2 Amine (amino) group

COOH Carboxyl group

Figure 2 shows the molecule formed from alanine and another amino acid.

Figure 2



0 1 . 2 Name the type of bond and the type of molecule formed when the two amino acids in **Figure 2** are joined.

[2 marks]

Type of bond Peptide bond

Type of molecule Dipeptide



0 1 . 3

Table 1 shows the R groups of six different amino acids.

Table 1

Amino acid	R group	Amino acid	R group
Alanine	CH ₃	Glycine	H
Aspartic acid	CH ₂ COOH	Serine	CH ₂ OH
Glutamine	(CH ₂) ₂ CONH ₂	Valine	CH(CH ₃) ₂

Use the information in **Table 1** to identify the amino acid joined to alanine in **Figure 2**.

[1 mark]

Serine

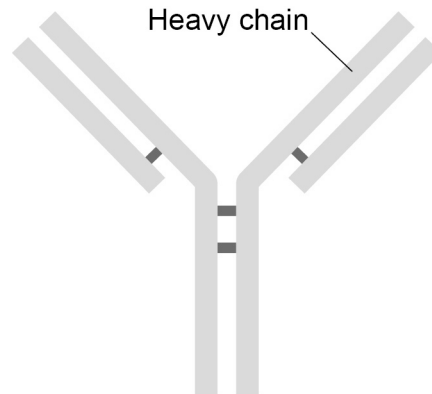
Question 1 continues on the next page

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0 1 . 4 Figure 3 represents the structure of an antibody.

Figure 3



The total number of amino acids in a particular antibody molecule is 1322

The ratio of amino acids in the heavy chains to the amino acids in the light chains is 2.13 : 1

Calculate how many amino acids there are in **one** heavy chain.

Give your answer to the nearest whole number.

[2 marks]

$$\text{Total parts} = 2.13 + 1 = 3.13$$

$$\text{Both heavy chains} = 1322 \times 2.13 \div 3.13 = 899.6$$

$$\text{One heavy chain} = 899.6 \div 2 = 449.8 = 450 \text{ (nearest whole number)}$$

450 amino acids

6



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ANSWER IN THE SPACES PROVIDED**

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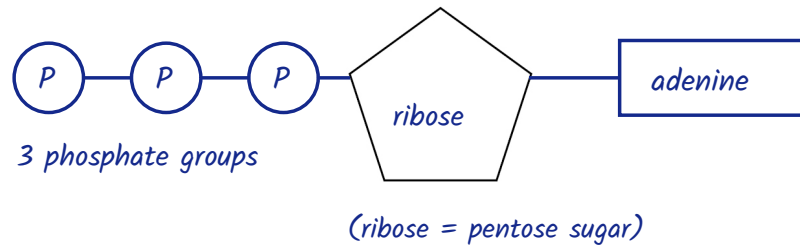


0 5

0 2 . 1

Figure 4 shows one component of an ATP molecule.

Figure 4



Complete **Figure 4** to show the structure of an ATP molecule.

Label all of its components.

[2 marks]

0 2 . 2

Describe how phosphate is released from ATP within cells.

Explain **one** way in which this phosphate can be used by cells.

[3 marks]

How phosphate is released from ATP

*ATP is hydrolysed (using water) into ADP and inorganic phosphate (Pi),
catalysed by the enzyme ATP hydrolase.*

One way in which phosphate can be used by cells

*The phosphate can be added to other substances (phosphorylation),
which makes them more reactive or changes their shape, e.g.
phosphorylating glucose at the start of glycolysis.*



0 2 . 3

Cells lining the ileum of mammals absorb glucose against a concentration gradient.

Describe how.

[3 marks]

Sodium ions are actively transported out of the epithelial cell into the blood by the sodium-potassium pump, using ATP.

This maintains a concentration (diffusion) gradient of sodium ions, with a lower sodium ion concentration inside the cell than in the lumen of the ileum.

Sodium ions then diffuse into the cell through a co-transporter protein in the cell-surface membrane, and glucose is co-transported with them into the cell against its concentration gradient.

The glucose then moves out into the blood by facilitated diffusion.

8

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03.1

Describe the semi-conservative replication of DNA.

[5 marks]

DNA helicase unwinds the double helix and separates the two strands by breaking the hydrogen bonds between complementary bases.

Both of the separated strands act as templates, with exposed bases.

Free DNA nucleotides line up and pair with their complementary bases on each template strand (A with T, G with C), and hydrogen bonds form between them.

DNA polymerase joins the adjacent nucleotides of the new strand together in a condensation reaction, forming phosphodiester bonds.

Each new DNA molecule therefore contains one original (template) strand and one newly made strand, which is why it is called semi-conservative.



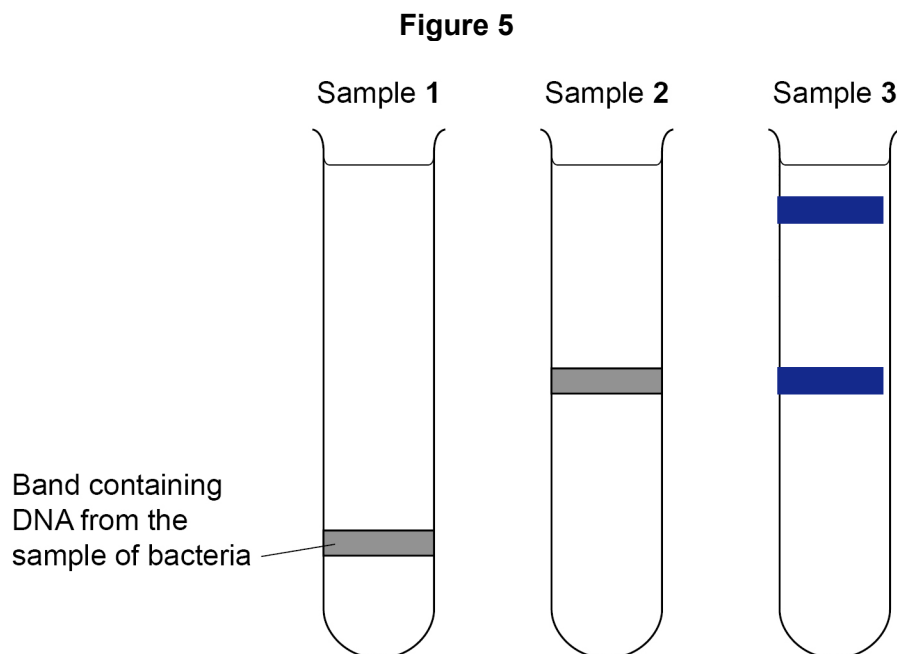
Scientists designed an experiment to investigate DNA replication.

They grew bacteria for several generations in a nutrient solution containing a heavy form of nitrogen (^{15}N). They obtained DNA from a sample of these bacteria (sample 1).

The scientists then transferred the bacteria to a nutrient solution containing a light form of nitrogen (^{14}N). They allowed the bacteria to grow and divide twice. After each division, they obtained DNA from a sample of bacteria (sample 2 and sample 3).

They suspended DNA from each sample of bacteria in a solution in separate tubes. They spun these tubes in a centrifuge at the same speed and for the same time. Based on its density, DNA settled as bands in each tube.

Figure 5 shows the scientists' results.



0 3 . 2

Explain the position of the DNA band in sample 2 in **Figure 5**.

[2 marks]

The band is halfway between a heavy (^{15}N) and a light (^{14}N) position because replication is semi-conservative.

Each DNA molecule has one original strand containing ^{15}N (heavy) and one new strand containing ^{14}N (light), so it has an intermediate density.

0 3 . 3

Complete sample 3 in **Figure 5** to show the result you would expect after two divisions.

[1 mark]

8

Turn over ►



0 4

This question is about genes and the genetic code.

0 4 . 1Define **locus**, **exon** and **universal genetic code**.**[3 marks]**

Locus The fixed position of a gene on a DNA molecule (on a chromosome).

Exon A base sequence of a gene that codes for an amino acid sequence.

Universal genetic code The same codon (base triplet) codes for the same amino acid in all organisms.

0 4 . 2**Table 2** shows the amino acids coded for by each mRNA codon.**Table 2**

First base	Second base				Third base
	Guanine (G)	Adenine (A)	Cytosine (C)	Uracil (U)	
G	Ala	Glu	Ala	Val	G
	Gly	Glu	Ala	Val	A
	Gly	Asp	Ala	Val	C
	Gly	Asp	Ala	Val	U
A	Arg	Lys	Thr	Met	G
	Arg	Lys	Thr	Iso	A
	Ser	Asn	Thr	Iso	C
	Ser	Asn	Thr	Iso	U
C	Arg	Gln	Pro	Leu	G
	Arg	Gln	Pro	Leu	A
	Arg	Hist	Pro	Leu	C
	Arg	Hist	Pro	Leu	U
U	Trp	stop	Ser	Leu	G
	stop	stop	Ser	Leu	A
	Cyst	Tyr	Ser	Phe	C
	Cyst	Tyr	Ser	Phe	U



Use **Table 2** to complete **Table 3** to show:

- the mRNA base sequence transcribed from the DNA base sequence
- the amino acid sequence translated from the mRNA base sequence.

[2 marks]

Table 3

DNA base sequence	G	C	T	C	T	A	C	A	G
mRNA base sequence	C	G	A	G	A	U	G	U	C
Amino acid sequence	Arg			Asp			Val		

0 4 . 3

Deletion of the third base thymine (T) in the **DNA** base sequence shown in **Table 3** would alter the primary structure of the polypeptide produced. However, substitution of the same base would not cause any alteration.

Use information in **Table 2** to explain why.

[3 marks]

Deleting the third base causes a frame shift, so every codon after it

changes. The mRNA would change from CGA GAU GUC to CGG AUG

UC..., so the second codon changes from GAU (Asp) to AUG (Met) and the following amino acids change.

If the third base (T) is substituted, the first mRNA codon CGA would become CGU, CGG or CGC.

All of these codons still code for arginine (Arg) because the genetic code is degenerate, so the primary structure stays the same.

8

Turn over for the next question

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0 5 . 1

Observable characteristics can be used to compare genetic diversity between species.

Give **two** other ways in which genetic diversity between species can be compared.

[2 marks]

1 *Comparing the base sequence of DNA (e.g. by DNA hybridisation).*

2 *Comparing the base sequence of mRNA, or the amino acid sequence of the same protein (e.g. using immunological comparisons with antibodies).*

0 5 . 2

A student compares the mean surface area of leaves on the ground from two populations of wild cherry trees.

Describe **and** explain how the student should collect these leaves to obtain valid data.

[2 marks]

Collect the leaves at random from the ground, e.g. using random coordinates on a grid, so there is no bias in which leaves are chosen.

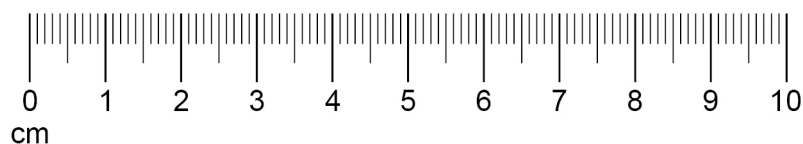
Collect a large number of leaves (at least 10, e.g. 30) from each population, so the sample is representative and a reliable mean can be calculated (and a statistical test can be used).



0 5 . 3

Another student investigated the variation in leaf length using the ruler shown in **Figure 6**.

Figure 6



The student measured the length of one leaf as 86 mm

State the uncertainty of this measurement **and** use this to calculate the percentage uncertainty in the length measurement.

[2 marks]

Uncertainty 1 mm

smallest division on the ruler = 1 mm

% uncertainty = $(1 \div 86) \times 100 = 1.163 \%$

Percentage uncertainty 1.16 %

6

Turn over for the next question

Turn over ►



0 6

A scientist investigated the effect of the lung disease emphysema on lung function.

They investigated lung function in:

- a person with emphysema
- a person with healthy lungs.

The scientist told each person:

- to breathe in fully
- then breathe out fully and as quickly as possible.

The scientist measured the volume of air exhaled in one breath.

Figure 7 shows the scientist's results.

Figure 7

Figure 7 not reproduced here due to third-party copyright restrictions.

The figure is adapted from

<https://www.thelancet.com/journals/lancet/article/PIIS0140673604168554/fulltext>

0 6 . 1

Forced expiratory volume (FEV₁) is the maximum volume of air that is breathed out in one second. FEV₁ is used to measure lung health.

What is the percentage decrease in FEV₁ for the person with emphysema compared with the healthy person?

Tick (✓) **one** box.

[1 mark]

23.1%

☐

30.0%

☐

42.5%

☒

73.9%

☐


0 6 . 2

Use **Figure 7** to determine the speed of exhalation, in $\text{dm}^3 \text{s}^{-1}$, for the person with healthy lungs **at** time = 2 s

Show your working.

[2 marks]

Draw a tangent to the healthy curve at $t = 2 \text{ s}$ (volume = 5 dm^3)

gradient = change in volume $\div$ change in time

$$= (5.8 - 4.2) \div (4 - 0) = 1.6 \div 4 = 0.4$$

Speed of exhalation 0.4 $\text{dm}^3 \text{s}^{-1}$

0 6 . 3

The main effects of emphysema on the lungs are the breakdown of:

- the walls of the alveoli
- the elastic tissue in the lungs.

Use this information and the data in **Figure 7** to suggest why gas exchange is reduced in a person with emphysema.

[3 marks]

Figure 7 shows the person with emphysema has a much lower FEV₁ and exhales a smaller total volume of air, so less air is ventilated and the oxygen concentration in the alveoli is lower.

Breakdown of the alveolar walls reduces the surface area for gas exchange (and any scar tissue increases the diffusion distance).

Loss of elastic tissue means less elastic recoil, so exhalation is more difficult and stale air stays in the alveoli. This reduces the concentration gradient of oxygen and carbon dioxide between the alveoli and the blood.

Question 6 continues on the next page

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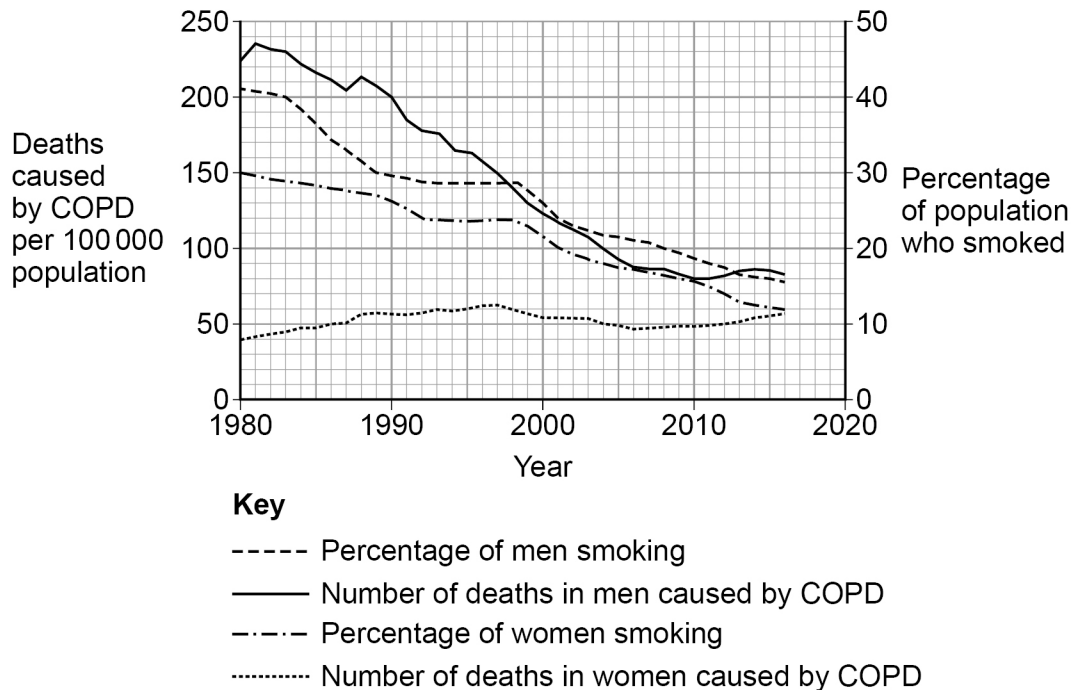


0 6 . 4

Chronic obstructive pulmonary disease (COPD) is the name for a group of lung diseases that cause breathing difficulties. This includes emphysema.

Figure 8 shows the number of deaths caused by COPD from 1980–2016. It also shows the percentage of the population who smoked, for the same time period.

Figure 8



A journalist looked at the data in **Figure 8** and concluded that smoking is a cause of COPD.

Evaluate this conclusion.

[3 marks]

Supports: for men there is a positive correlation, as the percentage of men smoking fell (about 41% to 16%), COPD deaths in men also fell (about 230 to 80 per 100 000).

Against: for women there is no correlation, as women smoking fell (30% to about 12%) but COPD deaths in women stayed about the same or rose slightly (about 40 to 60).

Correlation does not prove causation, and other factors were not considered, e.g. passive smoking, occupational exposure or better medical treatment.



07.1

Name the main carbohydrate transported through the phloem.

[1 mark]

Sucrose

07.2

In the storage tissues of plants, carbohydrates transported through the phloem can be converted into starch.

Explain **three** features of starch that make it a good storage molecule.

[3 marks]

1 *Starch is insoluble in water, so it does not affect the water potential of the cell and water does not enter by osmosis.*

2 *Amylose is coiled (helical), so it is compact and a lot can be stored in a small space.*

3 *Amylopectin is branched, so there are many ends for enzymes to act on and alpha-glucose is released quickly by hydrolysis for respiration. It is also a large molecule so it cannot leave the cell.*

Question 7 continues on the next page

Turn over ►



Scientists investigated the mass flow hypothesis in geranium plants.

The scientists:

- separated the phloem from the xylem in a part of the stem by placing an impermeable layer between them
- enclosed a leaf above the separated section, and supplied it with radioactive carbon dioxide ($^{14}\text{CO}_2$)
- illuminated the plant for 15 hours
- cut the stem into sections as shown in **Figure 9**
- measured the radioactivity in the phloem and xylem of each section.

Figure 9

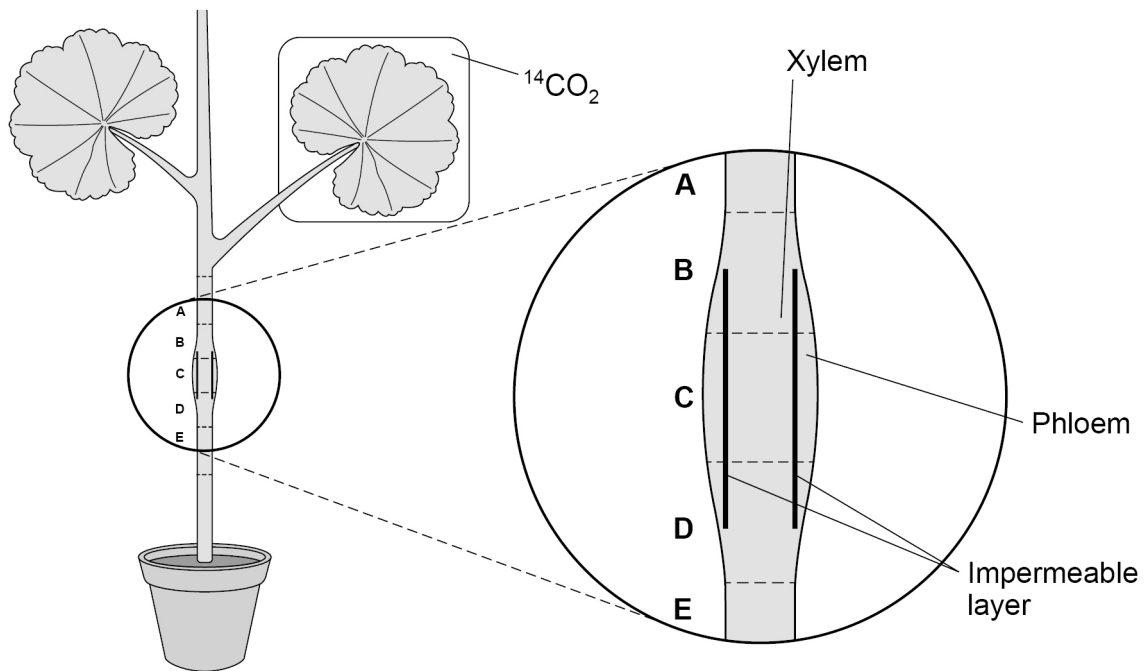


Table 4 shows the scientists' results.

Table 4

Section of tissue	Radioactivity in phloem / counts per minute	Radioactivity in xylem / counts per minute
A	41 100	24 210
B	2 761	755
C	130	74
D	101	47
E	157	75

07.3

The total radioactivity of the phloem and xylem tissues shown in **Table 4** was lower than the total radioactivity absorbed by the enclosed leaf.

Suggest **one** reason why.

[1 mark]

Some of the radioactive sugar was used by the leaf in respiration (or converted to starch / cellulose), or some stayed in the leaf and was not moved down the stem.

07.4

The mass flow hypothesis states that organic substances are transported through the phloem, from leaves to all parts of plants.

Evaluate whether the information from this investigation supports this hypothesis.

Do **not** refer to statistical tests or sample size in your answer.

[4 marks]

Supports: radioactivity in the phloem is higher than in the xylem in every section, e.g. 41 100 compared with 24 210 counts per minute in section A.

The leaf is the source, as it used the $^{14}\text{CO}_2$ to make radioactive organic substances in photosynthesis, and radioactivity was found in sections below the leaf, so these substances moved down the stem.

Against: some radioactivity was also found in the xylem, so organic substances may also be transported in the xylem.

Only sections below the leaf were tested, so there is no evidence of transport up to other parts (e.g. flowers), and movement down could be due to gravity. It was also only tested in geraniums.

9

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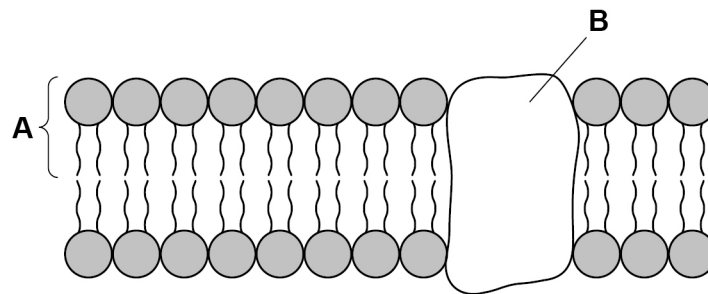
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0 8 . 1

Figure 10 shows a diagram of a cell-surface membrane.

Figure 10

Name **and** give the functions of the molecules labelled **A** and **B**.**[2 marks]**Molecule **A** name PhospholipidMolecule **A** function Forms a bilayer: a barrier to polar substances and ions, but lets lipid-soluble substances pass by simple diffusion.Molecule **B** name (Intrinsic / channel or carrier) proteinMolecule **B** function Allows large, polar or charged molecules and ions to pass through the membrane by facilitated diffusion or active transport.

0 8 . 2

A student investigated the effect of temperature on the permeability of cell-surface membranes in beetroot cells. Beetroot cells contain a red pigment that is not transported across intact cell-surface membranes.

The student:

- cut discs of beetroot tissue
- took five boiling tubes and placed two discs of beetroot into each boiling tube
- added water to the boiling tubes
- placed each boiling tube into a water bath at a different temperature for 30 minutes
- removed the discs and examined the water in each boiling tube.

Give **one** variable the student should have controlled in this investigation **and** explain why.

Do **not** refer to number of discs or length of time.

[2 marks]

Controlled variable The volume of water added to each boiling tube.

Explanation Different volumes of water would dilute the pigment by different amounts, which would affect the concentration (colour) of the solution, so the results would not be comparable.

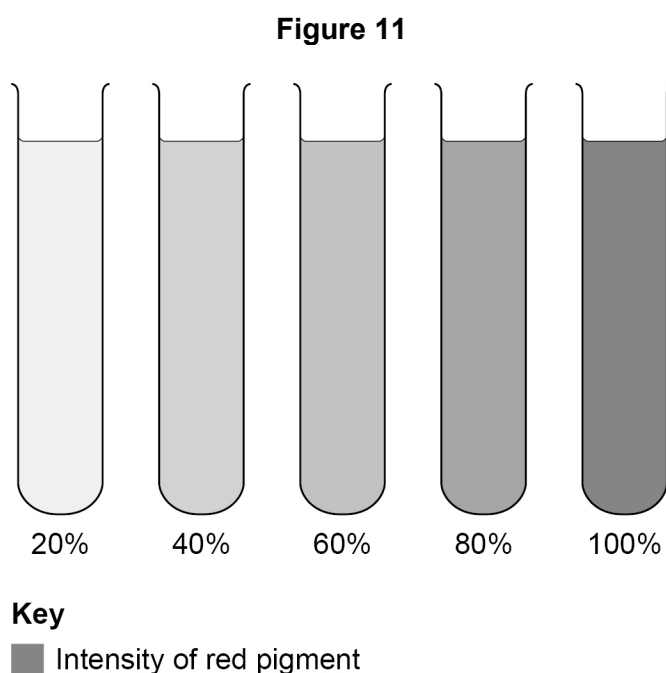
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Another student carried out the same investigation, ensuring that **all** variables were controlled.

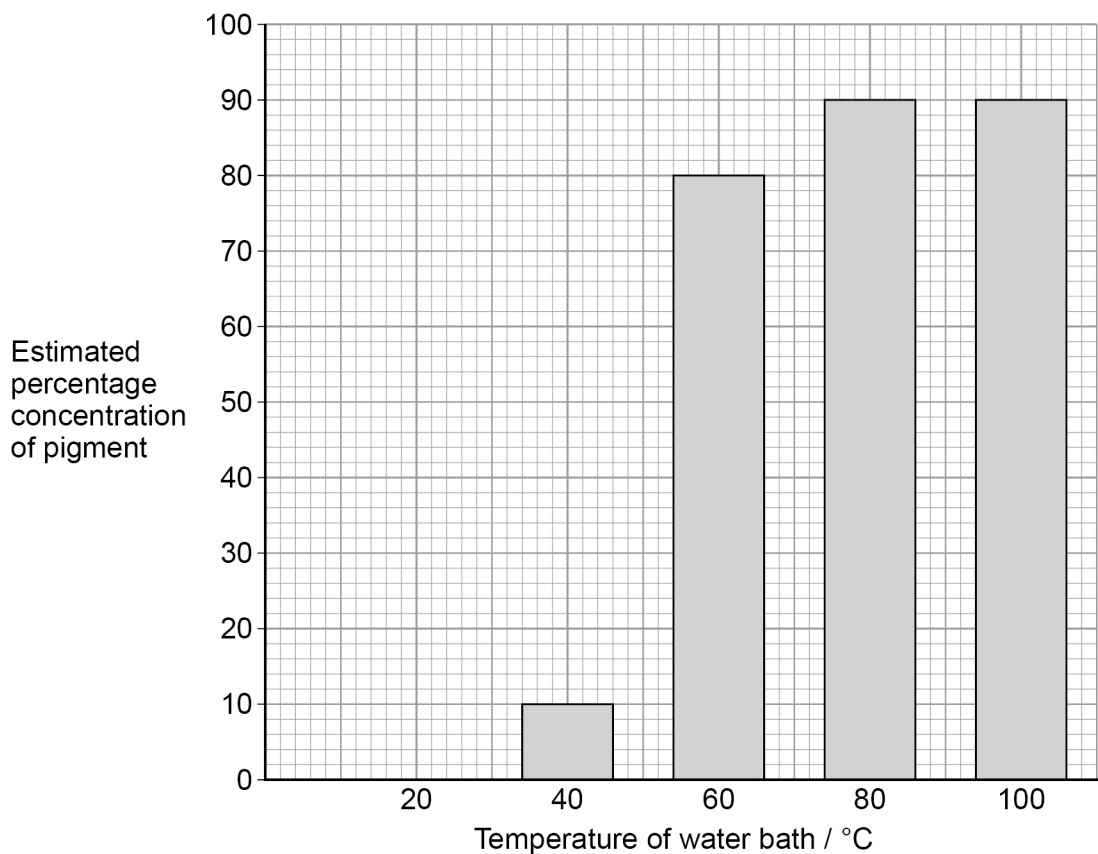
Figure 11 shows a dilution series the student prepared from 100% red beetroot pigment solution.



This student used the colours of the dilution series to estimate the percentage concentration of pigment in the boiling tubes at each temperature.

Figure 12 shows the student's results.



Figure 12

0 8 . 3

Describe and explain the general trend of the results in **Figure 12**.**[4 marks]**

As temperature increases, the percentage concentration of pigment increases (0% at 20 °C, 10% at 40 °C, 80% at 60 °C), but it levels off at 90% from 80 °C to 100 °C.

As temperature increases, the phospholipids gain more kinetic energy, so the membrane becomes more fluid and more permeable.

At high temperatures (60 °C and above) the membrane proteins denature, damaging the membrane, so more pigment leaks out of the cells.

At 80 °C the membrane is fully permeable (maximum damage), so increasing the temperature further does not release any more pigment.

Turn over ►

0 8 . 4

Describe how the student could use the dilution series (**Figure 11**, on page 22) and a colorimeter to determine an accurate measurement of the pigment concentration in the tubes at different temperatures.

[3 marks]

Use the colorimeter to measure the absorbance (or transmission) of each solution in the dilution series of known concentrations, zeroing it with distilled water first.

Plot a calibration curve of absorbance against percentage concentration of pigment.

Measure the absorbance of the water from each boiling tube, then read off the pigment concentration from the calibration curve.

11



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2 5

09

Read the following passage.

Penicillin-resistant *Staphylococcus aureus* (PRSA) bacteria have evolved by natural selection. From 1941, penicillin was used extensively to treat *S. aureus* infections. The first case of PRSA was reported in 1942. By the late 1960s, more than 80% of *S. aureus* bacteria were resistant to penicillin.

Many antibiotics have a beta-lactam ring in their chemical structure, which inhibits the synthesis of bacterial cell walls. PRSA have an allele of a gene *blaZ* that codes for an enzyme called beta lactamase. This enzyme hydrolyses beta-lactam rings in antibiotics such as penicillin. 5

The evolution of PRSA resulted in the development of new antibiotics, such as methicillin in 1960. However, by 1961, methicillin-resistant *S. aureus* (MRSA) were identified. In 2022, 675 cases of MRSA were reported in England. However, in 2023, the number of cases of MRSA rose to 787. Patients in hospitals are at greater risk of MRSA infections than the general population. 10

Use the information in the passage and your own knowledge to answer the following questions.

09.1

Penicillin-resistant *Staphylococcus aureus* (PRSA) have evolved by natural selection (lines 1–2).

Name the type of natural selection.

[1 mark]

Directional selection

09.2

By the late 1960s, more than 80% of *S. aureus* were resistant to penicillin (lines 3–4).

Explain why.

[3 marks]

The use of penicillin created a selection pressure, as penicillin killed the non-resistant (susceptible) S. aureus.

Bacteria with the blaZ allele for beta lactamase were resistant, so they were more likely to survive and reproduce, passing on the resistance allele.

Over many generations the frequency of the resistance allele in the population increased.



09.3

Many antibiotics have a beta-lactam ring in their chemical structure, which inhibits synthesis of bacterial cell walls (lines 5–6).

Suggest **two** reasons why this makes infections caused by PRSA difficult to treat.

[2 marks]

1 *PRSA produce beta lactamase which hydrolyses the beta-lactam ring, so many antibiotics are ineffective against PRSA.*

2 *So the bacteria can still synthesise cell walls and continue to reproduce, and new or different antibiotics are needed to treat them.*

09.4

In 2022, the population of England was 5.644×10^7

In 2023, the population of England was 5.672×10^7

Use information in lines 10–12 to calculate the increase in MRSA cases per 100 000 population.

Show your working.

[2 marks]

$$2022: 675 \div (5.644 \times 10^7 \div 100\,000) = 675 \div 564.4 = 1.19596$$

$$2023: 787 \div (5.672 \times 10^7 \div 100\,000) = 787 \div 567.2 = 1.3875$$

$$\text{Increase} = 1.3875 - 1.19596 = 0.19$$

Increase in MRSA cases per 100 000 population 0.19

Question 9 continues on the next page

Turn over ►



09.5

Patients in hospitals are at greater risk from MRSA infections than the general population (lines 12–13).

Suggest **and** explain **two** reasons why.

[2 marks]

1 *Patients are often ill or have weakened immune systems, so they are more susceptible to infection.*

2 *They are in close contact with many people in hospital, including other MRSA sufferers and staff, so MRSA is more likely to be passed to them.*

10

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