

Please write clearly in block capitals.

Centre number

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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.

INTERNATIONAL A-LEVEL BIOLOGY (9610)

Unit 5 Synoptic paper

Thursday 5 June 2025

07:00 GMT

Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

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).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

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

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	



J U N 2 5 B L 0 5 0 1

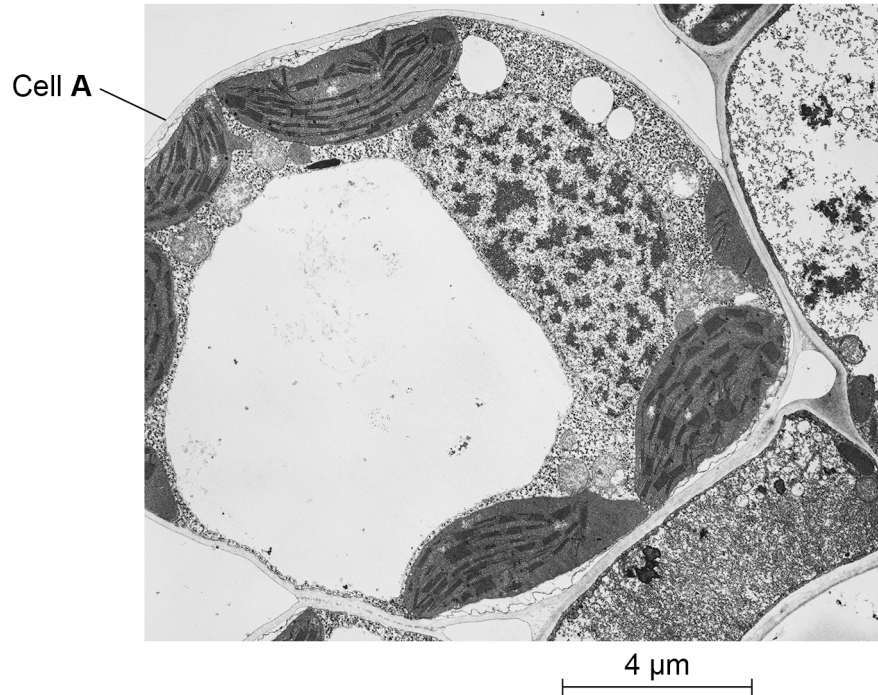
Answer **all** questions in the spaces provided

0 1

A plant leaf is an organ that provides food for the plant.

Figure 1 shows a section through cells in the leaf of a dicotyledonous plant.

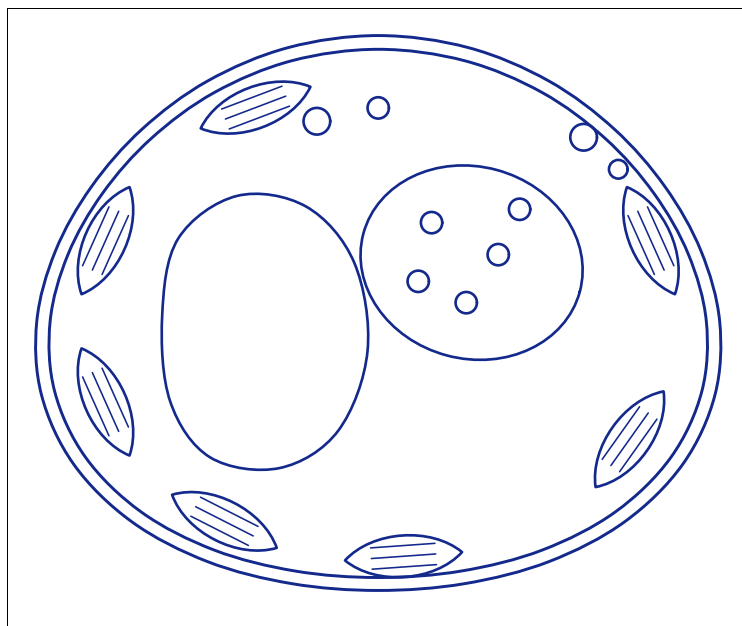
Figure 1



0 1 . 1

In the box below, draw a large, clear diagram of cell **A** in **Figure 1**.

[3 marks]



0 1 . 2 The scale bar in **Figure 1** represents $4\ \mu\text{m}$

Calculate the magnification of **Figure 1**.

[2 marks]

$$\text{length of scale bar} = 25\ \text{mm} = 25\ 000\ \mu\text{m}$$

$$\text{magnification} = \text{image size} \div \text{actual size}$$

$$= 25\ 000\ \mu\text{m} \div 4\ \mu\text{m} = 6250$$

$$\text{Magnification} = \quad \times 6250$$

0 1 . 3 Cells like cell **A** in **Figure 1** may contain 80–120 chloroplasts.

Only 7 chloroplasts can be seen in cell **A**.

Explain why so few chloroplasts are seen in cell **A**.

[2 marks]

The cell has been cut as a thin section, so only a thin slice through the cell is seen.

Most of the chloroplasts are not within the plane of the section; they are in other parts of the cell, above or below the slice.

Question 1 continues on the next page

Turn over ►



2,4-dichlorophenoxyacetic acid (2,4-D) is a selective weedkiller. 2,4-D can be sprayed on a crop of cereal plants, such as wheat or barley, to kill weeds.

Figure 2 shows a farmer spraying a cereal crop with 2,4-D.

Figure 2

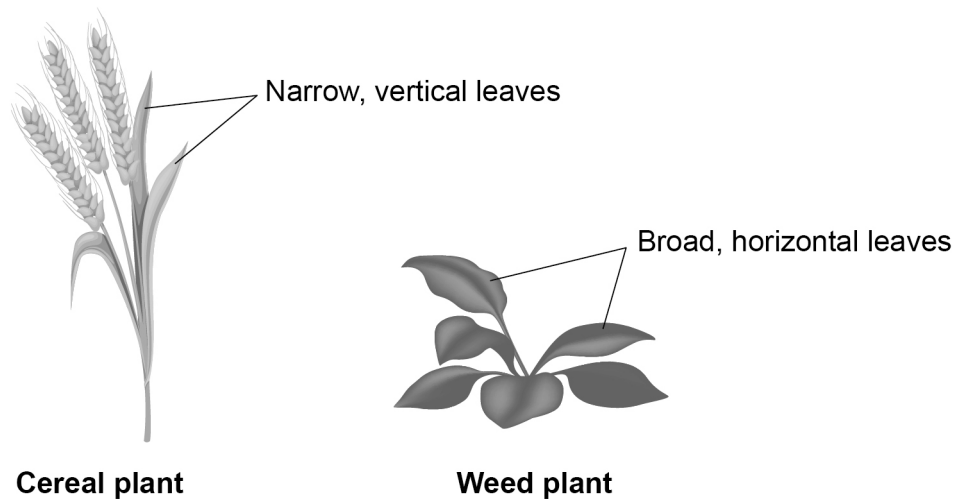


0 1 4

Cereal plants are monocotyledonous and have narrow, vertical leaves. Weeds are mainly dicotyledonous plants with broad, horizontal leaves.

Figure 3 shows a cereal plant and a weed plant.

Figure 3



Use this information to suggest why a farmer can use 2,4-D to kill weeds with broad leaves in a field of cereal crop.

[2 marks]

The cereal leaves are narrow and vertical, so they have a smaller surface area and the solution of 2,4-D falls (runs) off them, whereas it stays on the broad, horizontal leaves of the weeds.

So less 2,4-D enters (is absorbed by) the leaves of the cereal, which survives, but the weeds absorb enough to be killed.

Question 1 continues on the next page

Turn over ►



0 1 . 5

Suggest why some people do **not** agree with spraying crops with weedkillers such as 2,4-D.

[3 marks]

The spray may drift to other areas or be washed into waterways

(rivers).

2,4-D may kill, be toxic to or accumulate in other species (non-target plants and animals), decreasing biodiversity.

2,4-D may be toxic or harmful to humans, by contact or by eating contaminated crops or other species, e.g. it may be carcinogenic or cause allergies.

Repeated spraying may select for weeds that are resistant to 2,4-D.



Question 1 continues on the next page

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0 7

0 1 6

Cereal plants belong to the grass family of plants.

Grasses contain large amounts of the element silicon (Si) in the surface cells of stems and leaves. Scientists think the silicon may help to protect the plant from pathogens and from herbivores.

Scientists investigate the effects of silicon on the leaf structure of one species of grass and on the growth of two species of insect that feed on the grass. The grass leaves have two types of hair-like structures on their surfaces: 'macrohairs' and 'prickle cells'.

The scientists:

- grow 24 grass plants with their roots in a solution of mineral ions, including potassium silicate (Si+)
- grow 24 grass plants with their roots in a solution of mineral ions, with potassium chloride instead of potassium silicate (Si-)
- starve several insects of two species (species 1 and species 2) by not allowing them to eat for 24 hours
- put the insects on the grass plants for 48 hours
- remove the insects and starve them again for a further 24 hours.

Starving the insects for 24 hours allows all the food in their digestive systems to be lost as faeces.

Table 1 shows the measurements the scientists take from the leaves and the relative growth rates of the two species of insect.

Relative growth rate is calculated using:

$$\frac{\text{mass gained}}{\text{starting mass}}$$

Table 1

Measurements	Mean $\pm$ SE (standard error)		Probability from comparing means
	Si-	Si+	
Leaf thickness / mm	0.15 $\pm$ 0.004	0.16 $\pm$ 0.004	0.290
Number of macrohairs per mm ²	0.44 $\pm$ 0.12	0.68 $\pm$ 0.09	0.068
Number of prickle cells per mm ²	121.7 $\pm$ 4.6	99.5 $\pm$ 3.3	0.004
Prickle cell size / μm^2	176 $\pm$ 6.9	246 $\pm$ 10.1	0.002
Relative growth rate – insect species 1	-26.8 $\pm$ 8.7	-149.5 $\pm$ 6.1	< 0.001
Relative growth rate – insect species 2	-1.3 $\pm$ 3.7	-6.4 $\pm$ 1.1	0.002



The scientists conclude that silicon in large prickly cells on the surface of the leaves can reduce damage by insects.

Evaluate the scientists' conclusion.

Use information from the scientists' method and from **Table 1**.

[5 marks]

For: Si+ has significantly larger prickly cells ($P = 0.002 < 0.05$) and a significantly greater reduction in growth of both insect species ($P < 0.001$ and 0.002).

Not macrohairs or leaf thickness, as their increases are not significant ($P = 0.068$ and 0.290 , > 0.05).

Against: the number of prickly cells per mm^2 is significantly reduced in Si+ ($P = 0.004$), although this may be because they are larger.

Only 24 plants per treatment, one grass species and an unspecified number of insects, so may not be representative.

Only 48 hours, so long-term effect unknown; only two insect species, and species 2 showed less reduction than species 1, so cannot generalise to all insects.

There are no data about the degree of damage to the plants.

17

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0 2

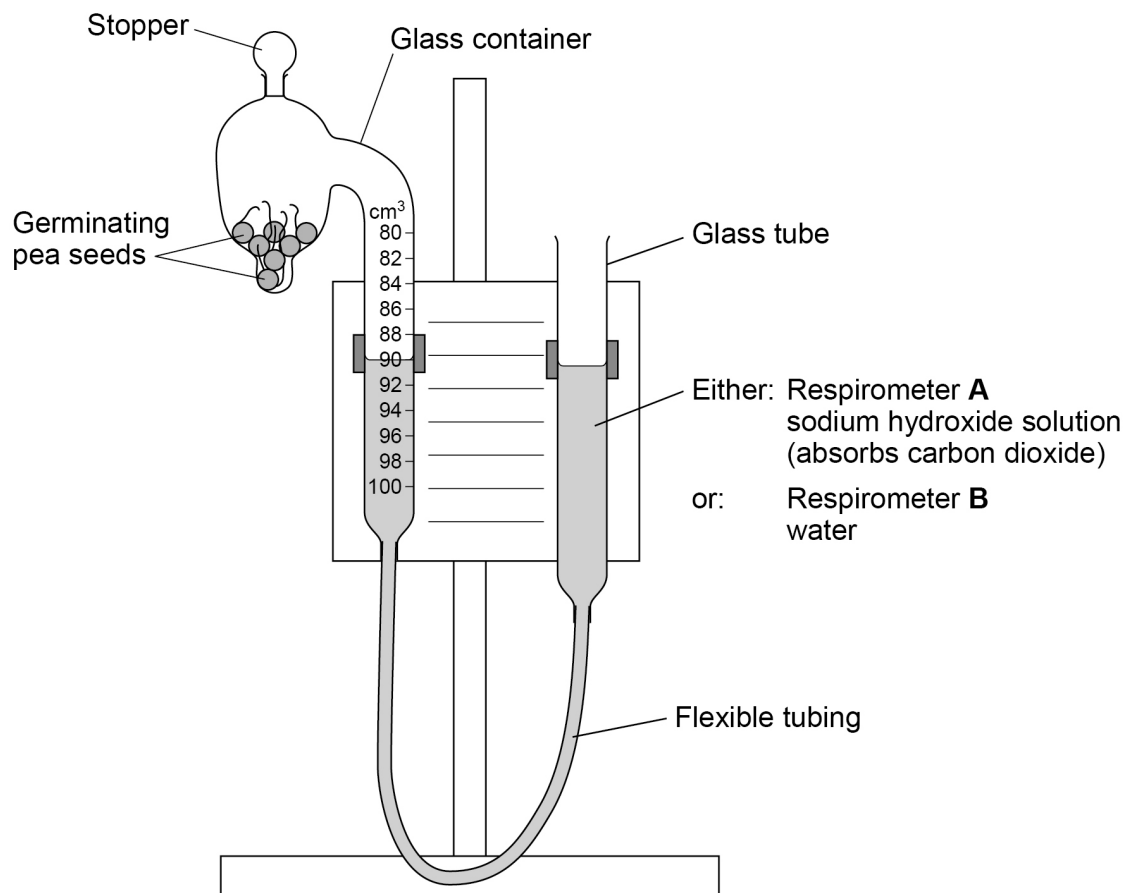
A respirometer is a piece of equipment used for measuring respiration.

Students use two respirometers (**A** and **B**) to measure:

- the rate of respiration of germinating pea seeds
- the respiratory quotient (RQ) of the pea seeds.

Figure 4 shows how the respirometers are set up.

Figure 4



The students:

- put 3.5 g of germinating pea seeds in each respirometer
- put both respirometers in a dark cupboard
- measure the volume of gas in respirometer **A** and in respirometer **B** at intervals for 48 hours.



0 2 . 1

Explain why the students keep the respirometers in a dark cupboard during the investigation.

[3 marks]

To prevent photosynthesis by the seeds (seedlings).

In the light, photosynthesis uses carbon dioxide and produces oxygen; in the dark there is only respiration, which uses oxygen and produces carbon dioxide.

So otherwise the students could not measure the oxygen uptake or the volume changes due to respiration alone.

0 2 . 2

The volume of gas in respirometer **A** decreased during the 48 hours of the investigation.

Explain why.

[3 marks]

Oxygen is consumed (taken up) by the seeds in aerobic respiration.

Carbon dioxide is produced in respiration.

The carbon dioxide is absorbed by the sodium hydroxide solution, so the volume of gas decreases by the volume of oxygen used.

Question 2 continues on the next page

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Table 2 shows the students' results.

Table 2

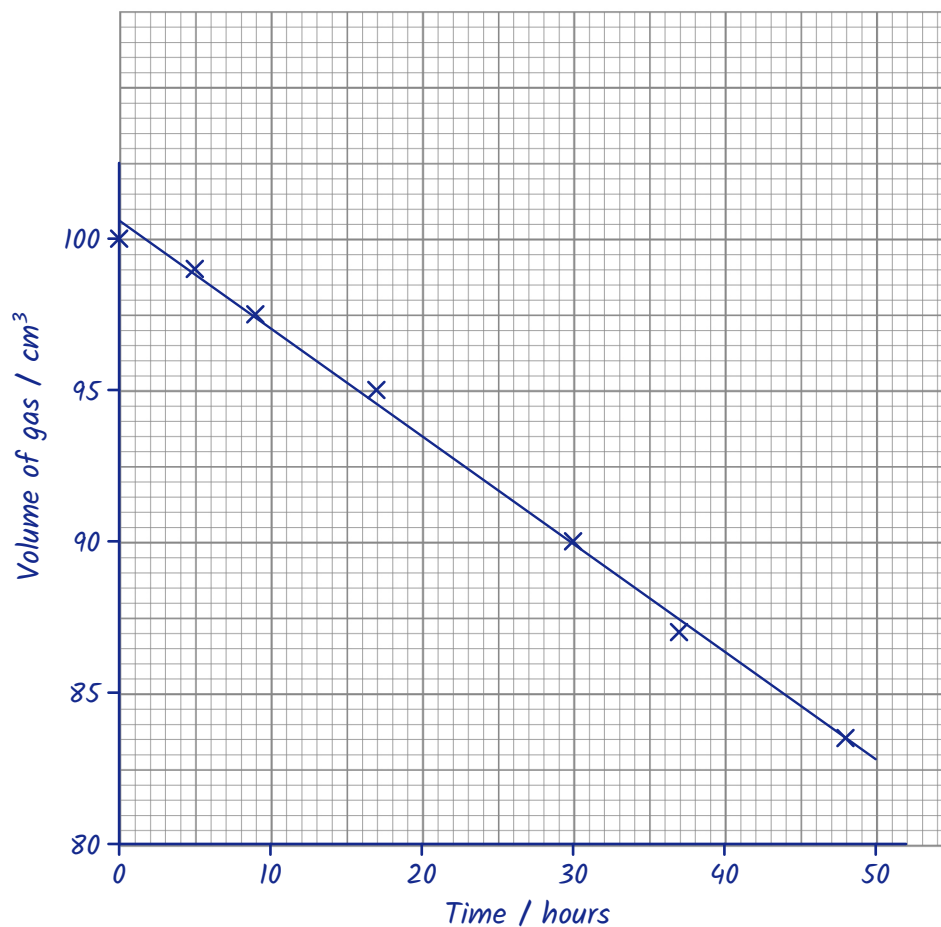
Time / hours	Volume of gas in respirometer / cm ³	
	A	B
0	100.0	90.0
5	99.0	89.5
9	97.5	89.5
17	95.0	90.0
30	90.0	90.5
37	87.0	90.0
48	83.5	90.0



0 2 . 3 Draw a graph of the results for respirometer A.

Draw a line of best fit on your graph.

[3 marks]



0 2 . 4 Calculate the rate of respiration of the germinating pea seeds.

Use data from your graph.

Give your answer in mm³ oxygen per gram of germinating pea seeds per hour, to the nearest whole mm³

[2 marks]

from line: 100.6 cm³ at 0 h, 82.8 cm³ at 50 h

O₂ used = 17.8 cm³ = 17 800 mm³ in 50 h

rate = 17 800 ÷ (50 × 3.5) = 101.7

Rate of respiration = 102 mm³ oxygen g⁻¹ h⁻¹

Question 2 continues on the next page

Turn over ►



0 2 . 5

Explain how the results for respirometer **B** show that the RQ of the germinating pea seeds is 1.0

[3 marks]

RQ = volume of CO₂ given out ÷ volume of O₂ taken in.

In respirometer B there is water, which does not absorb CO₂, and the volume of gas shows no overall change: it stays at about 90 cm³ for 48 hours.

So the volume of CO₂ produced equals the volume of O₂ consumed, so

RQ = 1.0

0 2 . 6

What does RQ = 1.0 suggest about the type of respiration **and** the respiratory substrate used by the germinating pea seeds?

[2 marks]

Type of respiration *Aerobic (respiration)*

Respiratory substrate *Carbohydrate (glucose)*

16



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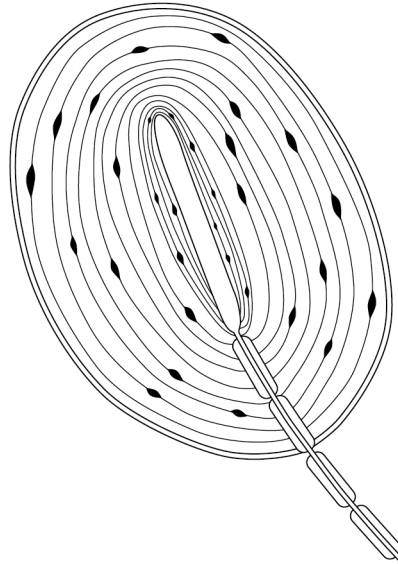


0	3
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The skin contains several types of receptor.

Figure 5 shows one type of touch receptor in human skin.

Figure 5



0	3	.	1
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Name the type of touch receptor shown in **Figure 5**.

[1 mark]

Pacinian corpuscle



0 3 . 2

Students investigate the distribution of touch receptors in the skin.

One student makes the hypothesis:

‘There will be more touch receptors per cm² in the fingertips than in the back of the hand.’

Suggest how the students could investigate this hypothesis.

[3 marks]

Apply two pin points, separated by different distances, to the person's skin in each region (fingertip and back of the hand).

Touch sometimes with one point and sometimes with two, with the person not looking, applying the same pressure each time.

Find the minimum distance consistently detected as two points for each region and compare; repeat at least twice more, calculate a mean for each area and apply a statistical test.

4

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0 4

A plant seed contains an embryo plant and a food store.

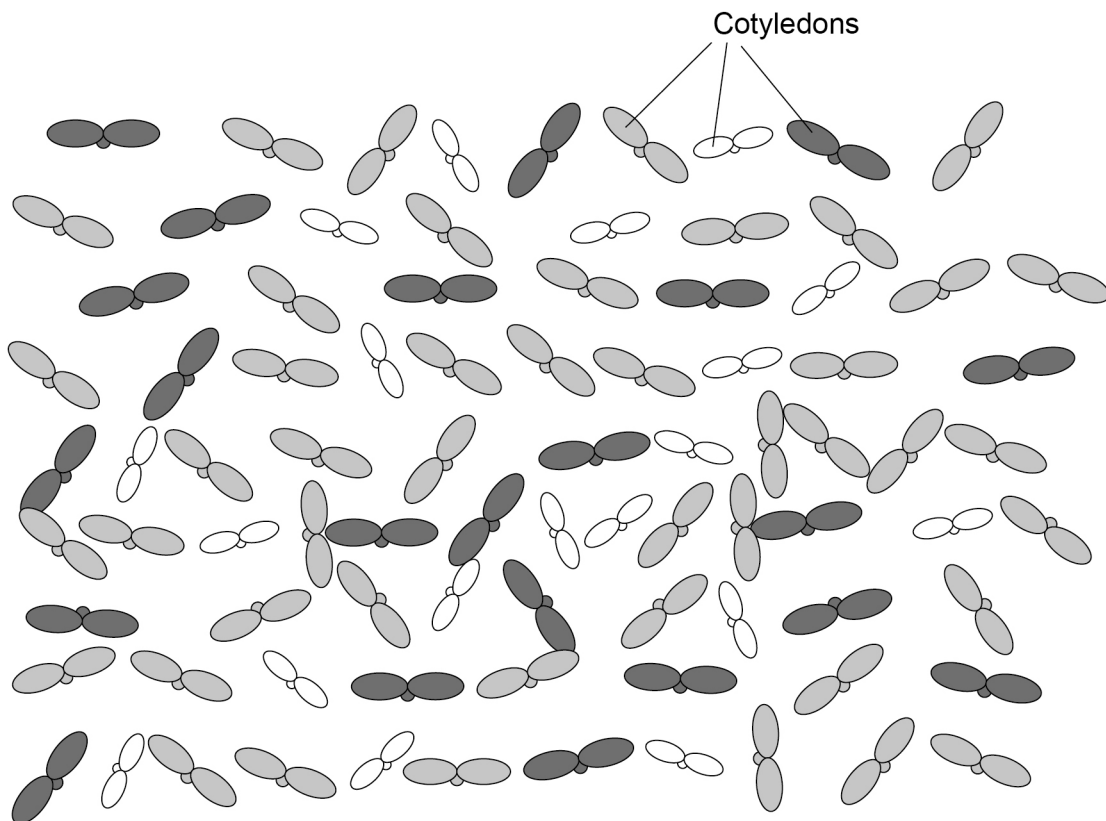
When a tomato seed germinates, the first leaf-like structures are the **cotyledons** from the seed.

A student puts seeds from a tomato plant in a tray of soil.

Figure 6 shows the seedlings after 7 days, seen from above.

Some of the seedlings have dark green cotyledons, some have light green cotyledons and some have white cotyledons.

Figure 6



Key



Seedling with dark green cotyledons



Seedling with light green cotyledons



Seedling with white cotyledons



0 4 . 1

Complete **Table 3** to show:

- the number of seedlings of each phenotype
- the ratio of the phenotypes.

[2 mark]

Table 3

Phenotype	Dark green	Light green	White
Number of seedlings	22	45	19
Ratio of phenotypes	1.00	: 2.05	: 0.86

In Questions **04.2** and **04.3**, use the following symbols: C^G = allele for dark green cotyledons C^W = allele for white cotyledons.

0 4 . 2

Predict the genotype of the tomato plant that produced the seeds the student used.

[1 mark]

 $C^G C^W$

0 4 . 3

Draw a genetic diagram to show how the tomato plant produced the seedlings shown in **Figure 6**.

Include the predicted ratio of offspring phenotypes.

[3 marks]

Parents: $C^G C^W$ x $C^G C^W$

Gametes: C^G C^W C^G C^W

	C^G	C^W
C^G	$C^G C^G$	$C^G C^W$
C^W	$C^G C^W$	$C^W C^W$

Offspring: $C^G C^G$ 2 $C^G C^W$ $C^W C^W$

Phenotypes: Dark green Light green White

Ratio: 1 : 2 : 1

Question 4 continues on the next page

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0 4 . 4 The student uses the χ^2 (chi-squared) test to analyse the results.

The student calculates a value of $\chi^2 = 0.396$

Table 4 gives probability values for different values of χ^2

Table 4

Degrees of freedom	Probability value					
	0.99	0.95	0.10	0.05	0.01	0.001
1	0.0002	0.0039	2.71	3.84	6.63	10.83
2	0.020	0.103	4.61	5.99	9.21	13.82
3	0.115	0.352	6.25	7.81	11.34	16.27
4	0.297	0.711	7.78	9.49	13.28	18.47

Explain if the student's results fit the expected ratio.

Use the calculated value of $\chi^2 = 0.396$ and data from **Table 4**.

[3 marks]

Yes, the results fit the expected 1 : 2 : 1 ratio.

There are 3 phenotype classes, so there are 2 degrees of freedom.

$\chi^2 = 0.396$ lies between 0.103 and 4.61, so P is between 0.95 and 0.10, so $P > 0.05$; χ^2 is less than the critical value of 5.99.

So the difference from the expected result is not significant and is due to chance, so the null hypothesis is accepted.



0 4 . 5

Figure 6 (on page 18) shows the seedlings 7 days after the tomato seeds were planted.

At 14 days after planting, there are **no** seedlings with white cotyledons.

Suggest why there are seedlings with white cotyledons at 7 days but **none** at 14 days.
[4 marks]

The white seedlings lack chlorophyll (chloroplasts), so they cannot trap light energy and cannot photosynthesise.

So they cannot make organic substances such as glucose, starch, lipids and proteins.

At 7 days they are still alive because they use the food store from the seed (cotyledons) for respiration and growth.

By 14 days this food store is used up, so there is no food left for respiration or for making cell structures, and the white seedlings die.

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Turn over for the next question

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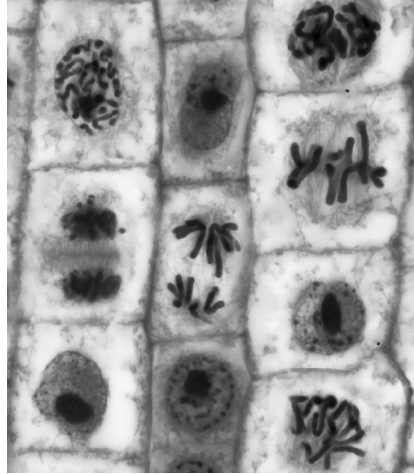


0 5

In plants, cells divide by mitosis during growth.

Figure 7 shows cells from a plant root.

Figure 7



0 5 . 1

Determine how many cells in **Figure 7** are in metaphase and in interphase.

[2 marks]

Metaphase 1

Interphase 4

0 5 . 2

Describe how you could prepare a slide of onion root tissue to show the stages of mitosis in **Figure 7**.

[3 marks]

*Place the end 2 to 5 mm of the onion root in hot hydrochloric acid,
then wash the root tip in water.*

*Cut the tip from the root, place it on a microscope slide and add a
stain, e.g. toluidine blue or aceto-orcein.*

*Cover with a coverslip and squash it by applying pressure, then blot off
excess stain from outside the coverslip.*



You are reminded that **2 marks** will be awarded
for the quality of written communication in **Question 6**.

0 6

Enzymes are catalysts. All living organisms use enzymes.

Catalase and DNA polymerase are two examples of enzymes.

0 6 . 1

Explain why living organisms need enzymes.

In your answer, include:

- how enzymes catalyse specific reactions
- **two** different types of reaction and a named enzyme that catalyses each type.

Do **not** refer to catalase or DNA polymerase in your answer.

[6 marks]

Enzymes are biological catalysts: they lower the activation energy of reactions, e.g. by putting strain on bonds in the substrate, so reactions occur quickly enough at moderate (body) temperatures; without enzymes, reactions would be too slow to sustain life.

Enzymes are proteins with a specific tertiary (3-D) shape of the active site. Each enzyme is specific because only its substrate is complementary to (fits) the active site, forming a specific enzyme-substrate complex (induced fit).

Condensation reactions: e.g. RNA polymerase joins RNA nucleotides in RNA synthesis (transcription), and ATP synthase joins ADP and P_i to make ATP. Rubisco catalyses CO_2 fixation with RuBP.

Hydrolysis reactions: e.g. amylase hydrolyses starch to maltose in digestion, and lipase hydrolyses lipids (triglycerides) to fatty acids and glycerol.

Question 6 continues on the next page

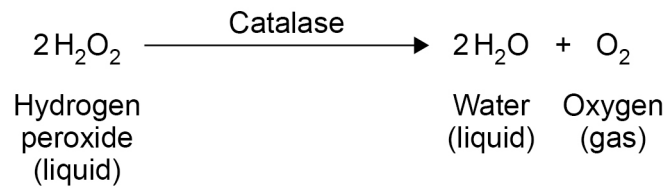
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0 6 . 2

Potatoes and sweet potatoes both contain the enzyme catalase.

Catalase controls the reaction:



Plan an experiment to find if potatoes **or** sweet potatoes contain a higher concentration of catalase.

[6 marks]

Grind equal masses (e.g. 10 g) of potato and of sweet potato, or cut discs of the same size and number with a cork borer.

Suspend each in equal volumes of buffer solution at a set pH, e.g. pH 7.

Keep both at a constant temperature, e.g. 30 °C, in a water bath and allow them to equilibrate.

Add the same volume and same concentration of hydrogen peroxide (H₂O₂) to each, e.g. 10 cm³ of 3%, in a flask sealed with a bung connected to a gas syringe (or an inverted measuring cylinder over water).

Collect the oxygen gas for the same time for each, e.g. 2 minutes, and record the volume; a larger volume shows a higher catalase concentration.

Repeat at least twice more for each and calculate a mean volume for each.

Compare the means and do a statistical test (t-test) to see if they are significantly different.



0 6 . 3

The enzyme *Taq* polymerase is a DNA polymerase enzyme made by the bacterium *Thermus aquaticus*.

Thermus aquaticus lives in hot water habitats.

Taq polymerase is used in the polymerase chain reaction (PCR).

In PCR, scientists treat DNA in a thermal cycler machine with stages at 55 °C, 72 °C and 95 °C

Explain how PCR is used for making large amounts of DNA from a small sample.

[6 marks]

A small sample of DNA is mixed with primers, free DNA nucleotides and

Taq polymerase in the thermal cycler.

The DNA is heated to 95 °C, which denatures the DNA: the hydrogen bonds break, producing separated single-stranded DNA.

It is cooled to 55 °C so primers can bind to one end of each single strand by complementary base pairing, and the two DNA strands remain separated.

Free nucleotides bind to the single-stranded DNA by complementary base pairing (hydrogen bonding).

It is heated to 72 °C, which is the optimum temperature for Taq polymerase; Taq is not denatured at 95 °C, as it comes from a bacterium in hot water.

Taq polymerase joins the nucleotides onto the primers, forming two-stranded DNA.

The cycle is repeated many times, doubling the DNA each cycle, giving many copies of the DNA.

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Quality of written communication [2 marks]

END OF QUESTIONS



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