

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 18 January 2024 07:00 GMT Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a pencil
- 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.
- In Question 6, 2 marks will be awarded for the quality of your written communication. You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

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



J A N 2 4 B L O 5 0 1

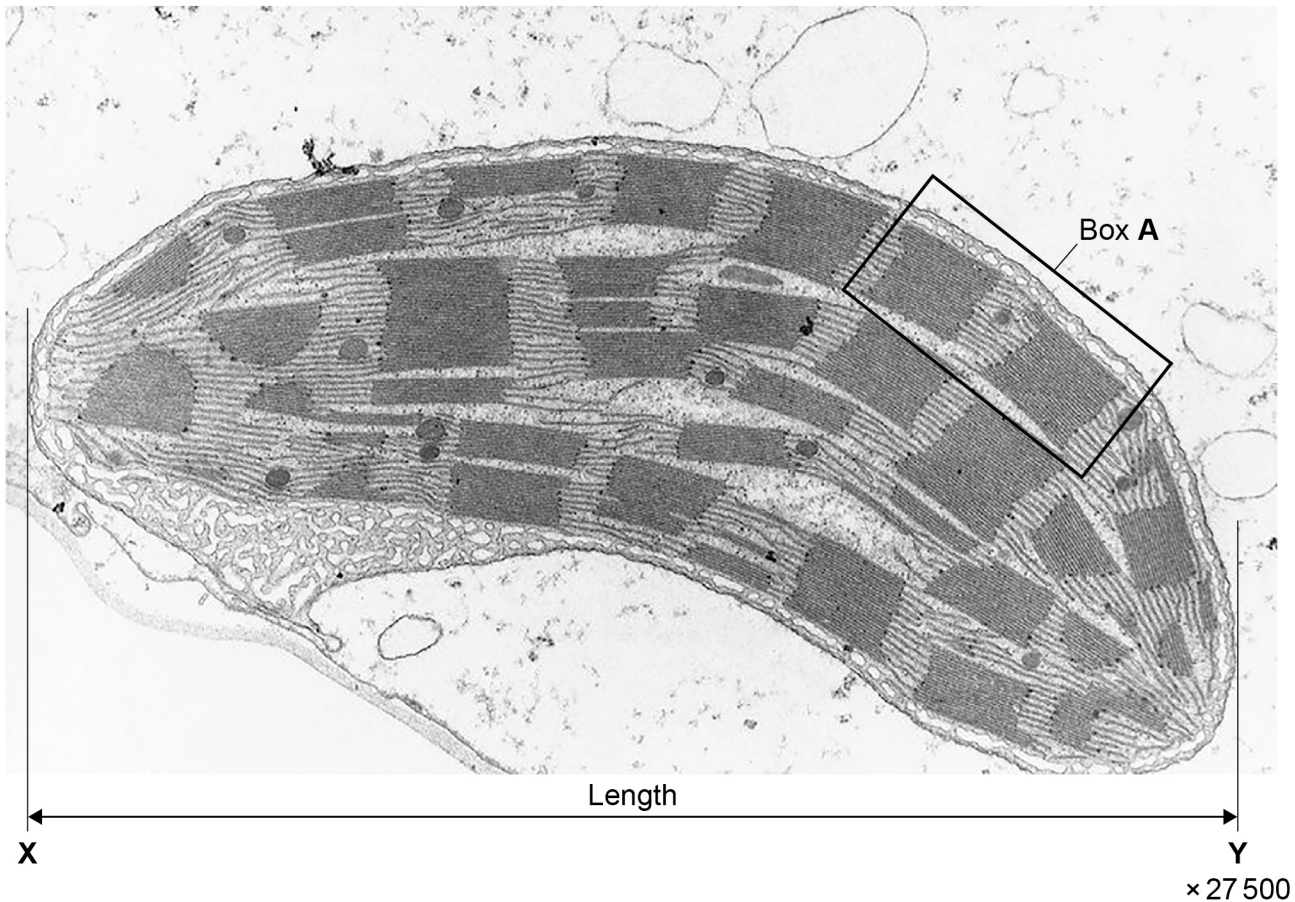
Answer **all** questions in the spaces provided.

0 1

Chloroplasts are cell organelles found in many eukaryotes.

Figure 1 shows a chloroplast from the leaf of a corn plant.

Figure 1



0 1 . 1

Scientists produced the image in **Figure 1** using a transmission electron microscope (TEM).

Give **two** pieces of evidence from **Figure 1** that a TEM was used.

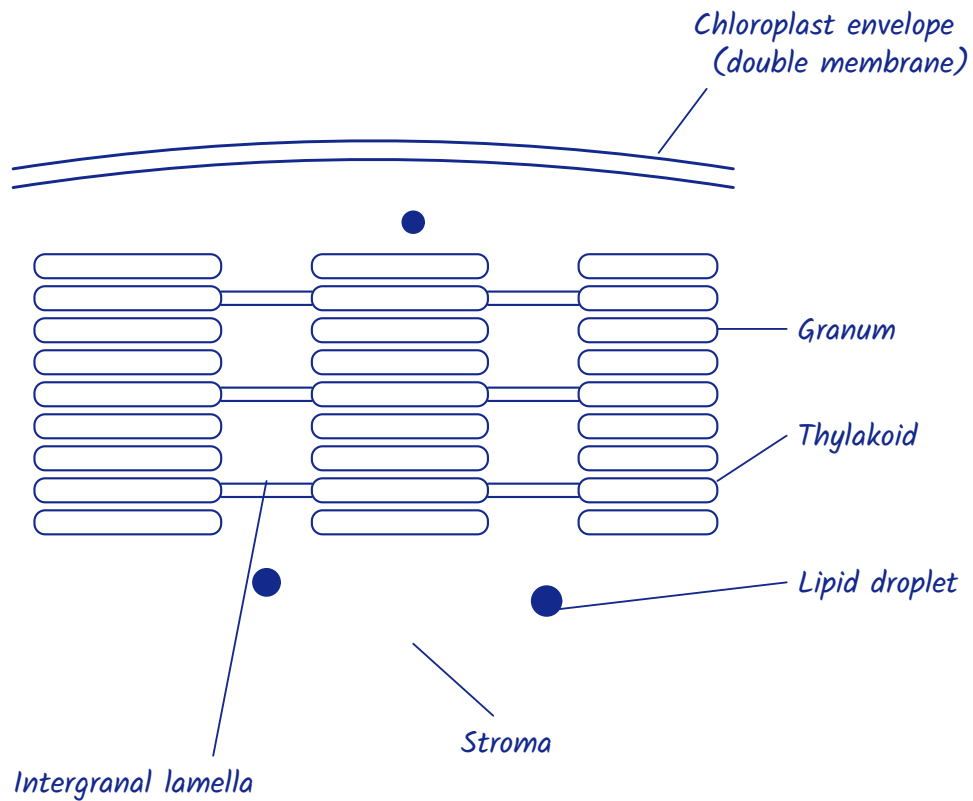
[2 marks]

1 *It has a much higher magnification ($\times 27\,500$) than a light microscope or an SEM could give for this detail.*

2 *Internal details, such as the thylakoid membranes in the grana, are visible: it has a very high resolution, and it is a section through the chloroplast.*



0 1 . 2

Draw a large, clear diagram of the structures in box **A** in **Figure 1**.**[3 marks]**

0 1 . 3

The magnification of **Figure 1** is $\times 27\,500$ Calculate the length, **X–Y**, of the actual chloroplast.

Give your answer in micrometres.

[2 marks]

$$\text{Measured length X to Y} = 160 \text{ mm} = 160 \times 1000 = 160\,000 \text{ }\mu\text{m}$$

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

$$= 160\,000 \div 27\,500 = 5.818 \text{ }\mu\text{m}$$

Length of the actual chloroplast, **X–Y** = 5.82 μm

Question 1 continues on the next page

Turn over ►



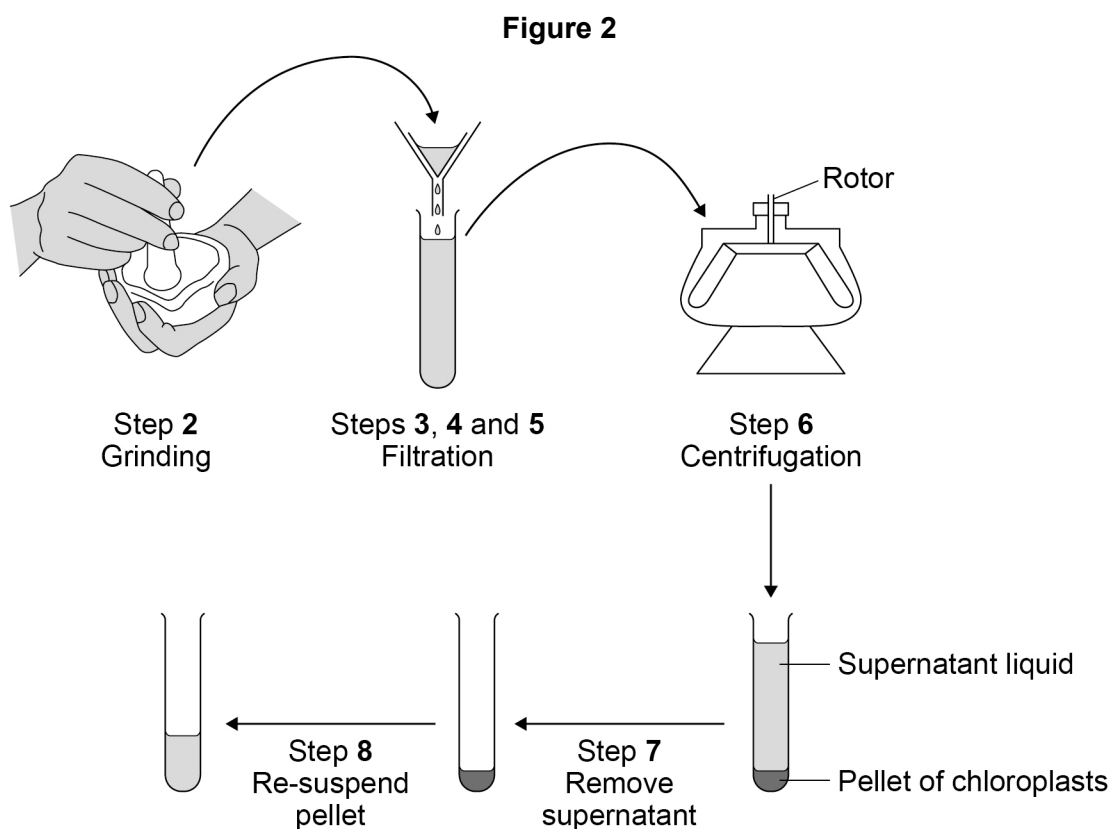
Students investigate the **light-dependent** reaction of photosynthesis.

The students first make a preparation of chloroplasts.

This is the method the students use.

1. Cut 3 small leaves into pieces with scissors.
2. Put the pieces of leaf into a mortar at 4 °C, add 20 cm³ of a cold isolation solution and grind the pieces of leaf with a pestle.
3. Put 4 layers of thin cloth in a funnel and wet the cloth with cold isolation solution.
4. Put several centrifuge tubes in a beaker of ice + salt + water and filter the mixture from step 2 into each centrifuge tube.
5. Check that each centrifuge tube contains the same volume of filtrate.
6. Spin the centrifuge tubes for 10 minutes in a bench centrifuge to give a green pellet of chloroplasts in each tube.
7. Pour off the supernatant liquid from each centrifuge tube.
8. Re-suspend the pellet of chloroplasts by mixing with 2 cm³ of cold isolation solution and store in a beaker of ice + salt + water.

Figure 2 gives a summary of the students' method.



The isolation solution (steps **2**, **3** and **8**) is a buffer solution at pH 7.0 and contains 0.4 mol dm^{-3} sucrose.

0 1 . 4

Give the reason why the students use a solution at pH 7.0 for isolating the chloroplasts.

[1 mark]

To prevent denaturation of the enzymes (proteins and cytochromes) in the chloroplasts, so the light-dependent reaction can still occur.

0 1 . 5

The 0.4 mol dm^{-3} sucrose solution has a water potential only slightly lower than the stroma inside the chloroplasts.

Explain why the students included 0.4 mol dm^{-3} sucrose in the isolation solution.

[2 marks]

The chloroplasts lose only a little water by osmosis (there is no net gain of water by osmosis).

So the chloroplasts remain intact: they do not burst, and they do not shrink too much.

0 1 . 6

Explain why the students check that each centrifuge tube contains the **same** volume of filtrate (step **5**) before placing the tubes in the centrifuge.

[2 marks]

So that opposite tubes are balanced in the centrifuge, which prevents damage to the centrifuge.

Also, different volumes would contain different numbers of chloroplasts, which would give different rates of reaction and prevent valid comparisons.

Question 1 continues on the next page

Turn over ►



The students use a reagent called DCPIP to see if the light-dependent reaction will occur under different conditions.

DCPIP solution is blue but becomes colourless when it combines with hydrogen atoms:

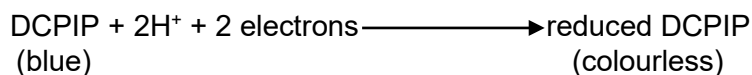


Table 1 shows how the students set up four test tubes and also shows the results.

Table 1

Tube	Tube Contents				Condition	Results	
	Chloroplast preparation / cm ³	Isolation solution / cm ³	Water / cm ³	DCPIP solution / cm ³		Colour at start	Colour after 15 mins
1	0.5	–	–	5	Light	Blue	Green
2	–	0.5	–	5	Light	Blue	Blue
3	0.5	–	–	5	Dark	Blue	Blue
4	0.5	–	5	–	Light	Green	Green

0 1 . 7 Each of tubes **2**, **3** and **4** is a control.

Explain how these tubes act as controls.

[2 marks]

Each tube differs in only one way from Tube 1: Tube 2 has no chloroplasts, Tube 3 has no light and Tube 4 has no DCPIP.

This shows the need for the missing factor (chloroplasts, light, DCPIP) in the reaction, i.e. that the colour change in Tube 1 is due to the light-dependent reaction.



0 1 . 8

Explain why the contents of **Tube 1** change from blue to green.

Use your knowledge of the light-dependent reaction.

[4 marks]

Light is absorbed by chlorophyll and the electrons in chlorophyll are excited; they are raised to a higher energy level.

These excited electrons are lost from the chlorophyll, which becomes oxidised.

The lost electrons are replaced by photolysis of water, which also releases H^+ ions (and oxygen): $2H_2O \rightarrow 4H^+ + 4e^- + O_2$.

The electrons and H^+ ions combine with (reduce) the DCPIP instead of NADP, so the DCPIP is decolourised.

The blue colour disappears, which leaves the green colour of the chloroplasts (chlorophyll) in the tube.

18

Turn over for the next question

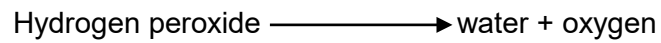
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0 2

Students investigate the effect of substrate concentration on the activity of the enzyme catalase.

Catalase catalyses the reaction:

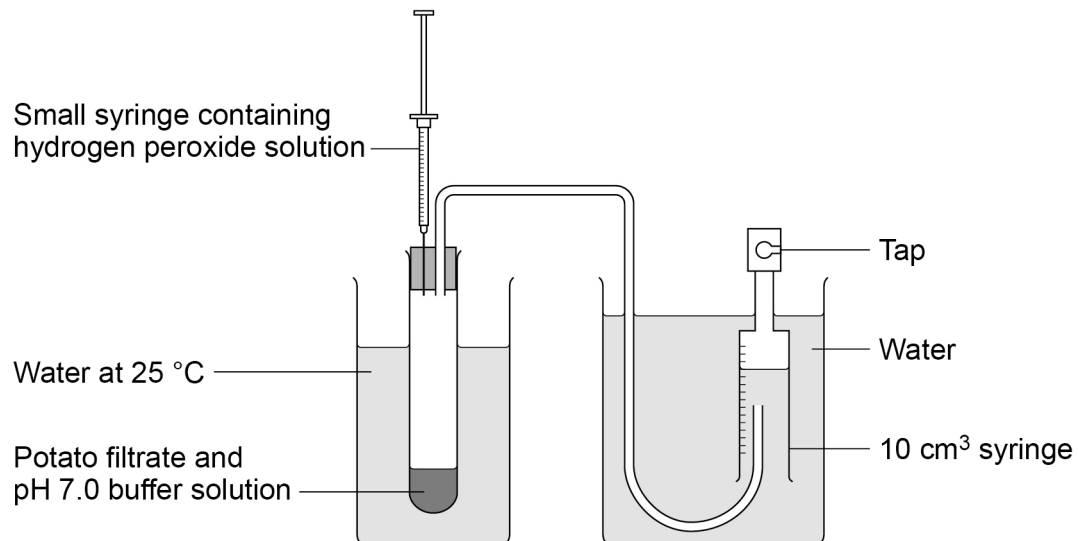


The students:

- grind up 150 grams of potato tissue in 100 cm³ of water
- filter the mixture and use the filtrate as their source of catalase
- collect the oxygen produced in the reaction in a 10 cm³ syringe.

Figure 3 shows the equipment the students use.

Figure 3



Question 2 continues on the next page

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ANSWER IN THE SPACES PROVIDED**

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Table 2 shows the students' results.

Table 2

Concentration of hydrogen peroxide / %	Mean volume of oxygen collected $\pm$ SD / cm ³
100	9.6 $\pm$ 0.24
80	9.5 $\pm$ 0.12
60	9.2 $\pm$ 0.62
40	8.0 $\pm$ 0.61
20	4.6 $\pm$ 0.36
10	2.4 $\pm$ 0.28
0	0.0 $\pm$ 0.00



0 2 . 1

Describe in detail how the students could use the equipment shown in **Figure 3** to obtain the results shown in **Table 2**.

[7 marks]

Put a constant volume (e.g. 5 cm³) of potato filtrate and the same volume of pH 7.0 buffer solution in the boiling tube.

Incubate the tube in the water bath at 25 °C for 5 to 10 minutes so that it reaches the temperature.

Fill the 10 cm³ syringe with water by opening the tap and submerging it in the water; close the tap and clamp it upside down.

Inject a fixed volume (e.g. 1 cm³) of hydrogen peroxide solution and start the stop clock; measure the volume of O₂ collected in the syringe in a given time, e.g. 2 minutes.

Before reading the volume, raise the syringe so the water levels inside and outside it are the same (to equalise pressure).

Repeat with the same volume of each of the different concentrations of H₂O₂ (100, 80, 60, 40, 20, 10 and 0%), made by diluting the 100% solution with distilled water, e.g. 4 cm³ + 1 cm³ water for 80%.

Wash out the boiling tube between experiments and use fresh filtrate.

Repeat at least twice more at each concentration and calculate the mean volume and standard deviation for each concentration.

Question 2 continues on the next page

Turn over ►



0 2 . 2

Describe how the students should display their results in a graph.

Give a reason for your choice of graph.

[3 marks]

Plot a line graph with the concentration of hydrogen peroxide (the independent variable) on the x-axis and the mean volume of oxygen collected (the dependent variable) on the y-axis.

Add error bars to each point to represent $\pm$ the standard deviation.

A line graph is used because both variables are continuous.

0 2 . 3

One student states:

'There is no significant difference between the results with 40% hydrogen peroxide and 60% hydrogen peroxide.'

Use data from **Table 2** to give evidence to support the student's statement.

[2 marks]

The standard deviations overlap.

At 40%: $8.0 + 0.61 = 8.61 \text{ cm}^3$; at 60%: $9.2 - 0.62 = 8.58 \text{ cm}^3$, so the ranges overlap (8.58 is less than 8.61).



0 3

Scientists can produce fragments of DNA using different methods.

0 3

1

In one method, the scientists produce complementary DNA (cDNA) from mRNA.

Name the type of enzyme that produces cDNA from mRNA.

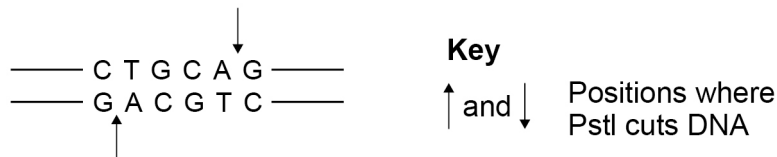
[1 mark]

Reverse transcriptase

In another method, the scientists use an enzyme that cuts DNA into smaller fragments.

An enzyme called PstI cuts DNA at the specific base sequence shown in **Figure 4**.

Figure 4



0 3

2

What general name is given to enzymes such as PstI?

[1 mark]

Restriction endonuclease (restriction enzyme)

0 3

3

PstI produces DNA fragments with sticky ends.

Why are sticky ends useful in genetic engineering?

[1 mark]

They allow pieces of DNA to be joined because the sticky ends are complementary, so they join by base pairing.

Question 3 continues on the next page

Turn over ►



The scientists prepare a sample containing many identical molecules of DNA.

The DNA molecules are linear (non-circular).

The scientists treat a sample of the DNA with PstI (**Sample 1**).

The scientists leave a second sample of the DNA untreated (**Sample 2**).

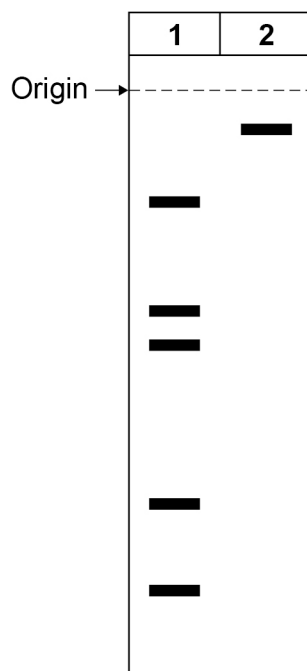
The scientists carry out gel electrophoresis on each of the two samples.

Gel electrophoresis separates pieces of DNA depending on their electrical charge and their mass.

Small pieces of DNA move further from the origin than large pieces of DNA.

Figure 5 shows the results.

Figure 5



Key

Sample 1 = DNA treated with PstI

Sample 2 = Untreated DNA

0 3 . 4

How many times did the base sequence **CTGCAG** occur in the untreated DNA?
GACGTC

[1 mark]

4



0 3 . 5

In a certain genetic condition, **one** of the **CTGCAG** sequences is changed.
GACGTC

Predict how this would change the appearance of **Sample 1** in **Figure 5**.

[2 marks]

*Only 4 bands would be seen in Sample 1, because two of the bands
merge (the two fragments either side of the changed sequence are no
longer cut apart).*

*A new band would be formed at a heavier position, nearer to the origin
(higher up the gel).*

6

Turn over for the next question

Turn over ►



0 4

In domestic cats, some fur colours are controlled by a gene on the X chromosome.

A scientist crosses black cats with orange cats.

The results are different depending on which parent is black and which is orange.

Cross 1: Black male cats are crossed with orange female cats. All the male offspring are orange and all the female offspring are 'tortoiseshell' (a mixture of black and orange fur).

Cross 2: Orange male cats are crossed with black female cats. All the male offspring are black and all the female offspring are, again, tortoiseshell.

In Questions **04.1** and **04.2**, use the following symbols:

X^B = an X chromosome with the allele for black fur

X^b = an X chromosome with the allele for orange fur

Y = a Y chromosome.

0 4 . 1

Complete the **two** genetic diagrams to explain the scientist's results.

[4 marks]

Cross 1**Black male × orange female**Parental
genotypes $X^B Y \times X^b X^b$

Gametes

 X^B and Y ; X^b

$\sigma \setminus \phi$	X^b	X^b
X^B	$X^B X^b$	$X^B X^b$
Y	$X^b Y$	$X^b Y$

Offspring
genotypes $X^B X^b$ and $X^b Y$ Offspring
phenotypes

Tortoiseshell Orange

Offspring
sex

Female Male

Cross 2**Orange male × black female**Parental
genotypes $X^b Y \times X^B X^B$

Gametes

 X^b and Y ; X^B

$\sigma \setminus \phi$	X^B	X^B
X^b	$X^B X^b$	$X^B X^b$
Y	$X^B Y$	$X^B Y$

Offspring
genotypes $X^B X^b$ and $X^B Y$ Offspring
phenotypes

Tortoiseshell Black

Offspring
sex

Female Male



0 4 . 2

The scientist then crosses orange male cats with tortoiseshell female cats.

Table 3 shows the offspring.

Table 3

Black male	Orange male	Orange female	Tortoiseshell female
12	7	13	8

The scientist expected a 1 : 1 : 1 : 1 ratio of phenotypes.

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

The scientist calculates a value of $\chi^2 = 2.60$

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	0.002	0.004	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 scientist's results in **Table 3** fit the expected ratio.

Use the calculated value of $\chi^2 = 2.60$ and data from **Table 4**.

[3 marks]

Yes, the results fit the expected ratio. There are 4 phenotypes so there are 3 degrees of freedom.

$\chi^2 = 2.60$ lies between 0.352 and 6.25, so P is between 0.95 and 0.10, i.e. $P > 0.05$; χ^2 is less than the critical value of 7.81.

So the difference from the expected ratio is not significant and is due to chance: accept the null hypothesis.

7

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0 5

Leukaemia is a cancer of the blood cells.

Vincristine and resveratrol are two drugs that might be useful in treating leukaemia.

- Vincristine – an inhibitor of microtubule formation.
- Resveratrol – an antioxidant.

0 5**1**

Microtubules are components of spindle fibres.

Explain how an inhibitor of microtubule formation could be useful in cancer treatment.

[2 marks]

Without microtubules no spindle can form, so the chromatids

(chromosomes) cannot join to the spindle and cannot be separated by the microtubules.

This prevents mitosis (cell division), so the cancer cells cannot divide and the tumour cannot grow.

0 5**2**

An antioxidant is a chemical that prevents free radical formation.

Free radicals can damage DNA.

Suggest **one** way an antioxidant might help to prevent cancer.

[1 mark]

It reduces mutations in proto-oncogenes (preventing their activation to oncogenes) or in tumour suppressor genes (preventing their inactivation).

Question 5 continues on the next page

Turn over ►



Scientists investigate the effects of vincristine and resveratrol on one type of leukaemia.

The scientists put human leukaemia cancer cells into 48 mice.

The scientists then divide the mice into 3 groups of 16 mice.

The scientists treat the mice once every 2 days for 4 weeks, as follows:

Group 1: inject the mice with vincristine (0.5 mg kg^{-1} body mass)

Group 2: inject the mice with resveratrol (10.0 mg kg^{-1} body mass), dissolved in dimethyl sulfoxide (DMSO)

Group 3: inject the mice with DMSO only.

0 5 . 3

The scientists inject a certain mass of each drug per kilogram body mass into each mouse instead of the same mass into each mouse.

Explain why.

[3 marks]

The mice vary in size (body mass).

Giving a dose per kg of body mass gives the same concentration of the drug in the body fluids of each mouse.

Otherwise the effects of the drug in different mice could not be compared, so valid results could not be obtained.

0 5 . 4

Explain why the scientists include group 3 in the investigation.

[2 marks]

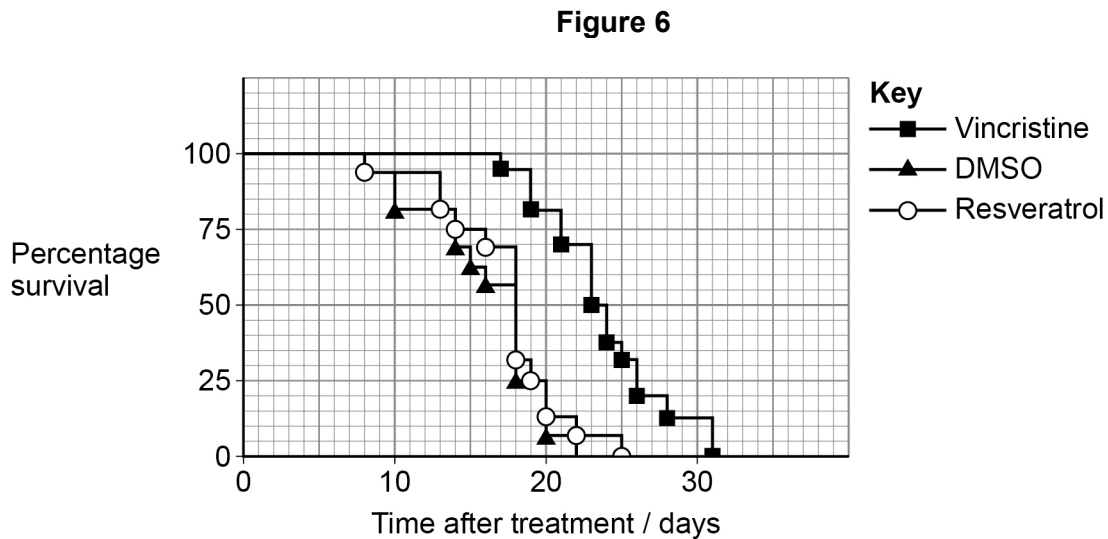
Group 3 is a control because the resveratrol in group 2 is dissolved in DMSO, so group 2 receives resveratrol and DMSO.

Otherwise the scientists could not tell whether any effect in group 2 was due to the resveratrol or to the DMSO.



The scientists calculate the percentage survival of the mice after the treatment.

Figure 6 shows the results.



0 5 . 5

Evaluate the use of vincristine and resveratrol in treating cancer.

Use information from the scientists' method and from the results in **Figure 6**.

[4 marks]

Vincristine is better than resveratrol: mice survive longer (50% survival at about 23 days, not 17).

Resveratrol is ineffective, as it gives similar results to the control (DMSO). No mice survive more than 31 days, so neither drug is very useful.

The dose of vincristine is much lower than resveratrol (only 1/20), yet vincristine is still more effective.

Only one form of cancer (leukaemia) was investigated, only in mice, so the effect on humans and any side effects are not known. Only 16 mice in each group (48 in total), so the results may not be representative.



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

0	6
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Carbohydrates are used by all living organisms.

0	6	.	1
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The human diet includes carbohydrates.

Describe how carbohydrates in the diet:

- are made available to the body's cells
- are used by the body's cells.

Do **not** refer to hormones in your answer.

[6 marks]

Starch is digested (hydrolysed) to maltose by amylase in saliva and in pancreatic juice.

Maltose is digested to glucose by membrane-bound maltase in the small intestine (sucrose and lactose by sucrase and lactase).

Glucose is absorbed into the epithelial cells by co-transport with Na⁺ ions (active transport) and by facilitated diffusion, then into the blood.

It is transported in solution in the blood plasma to the body cells, which it enters by facilitated diffusion through transport (carrier)

proteins.

In cells glucose is a source of energy (ATP) via respiration: glycolysis, Krebs cycle (oxidation via NAD and FAD) and the electron transport chain.

Excess glucose is stored as glycogen for energy storage, or converted to glycerol and fatty acids (lipids) and to amino acids (proteins).

Glycoproteins: antibodies (immune response) and antigens, e.g. ABO blood groups. Ribose is used in RNA, ATP and NAD; deoxyribose in DNA (genes). Glucose maintains the water potential of the blood for body cells.



0 6 . 2

You are given a cloudy white suspension in a test tube.

Describe how you would show that the suspension is a mixture of:

- starch
- reducing sugar
- non-reducing sugar.

Include full experimental details of your procedure.

[6 marks]

Remove a sample and add iodine in potassium iodide solution: blue-black shows starch is present.

Filter the rest of the suspension to remove the starch; test a sample of the filtrate with iodine solution, and if blue-black re-filter until it stays yellow (starch-free).

Take a sample of the starch-free filtrate, add an equal volume of Benedict's solution and heat in a boiling water bath for 5 minutes: an orange (red) precipitate shows reducing sugar.

Spin down the precipitate in a centrifuge (or filter it off) to remove the reducing sugar; take the supernatant, add dilute HCl and heat in a boiling water bath to hydrolyse the non-reducing sugar.

Cool and neutralise with sodium hydrogencarbonate (alkali), testing with indicator paper.

Add Benedict's solution and heat: an orange precipitate now shows non-reducing sugar was present.

Question 6 continues on the next page

Turn over ►



0 6 . 3

Although glucose enters and leaves the blood at variable rates, the concentration of glucose in the blood is kept between 4.4 and 6.6 mmol dm⁻³

Describe how hormones control the concentration of glucose in the blood.

[6 marks]

If blood glucose is too high, β cells in the pancreas detect this and release insulin.

Insulin combines with receptors on the cell-surface membranes of liver and muscle cells.

This causes more glucose channel (carrier) proteins to be inserted into the membrane, so there is more glucose uptake.

Enzymes are activated that convert glucose into glycogen (glycogenesis) and into fatty acids (lipid), and more glucose is used in respiration.

If blood glucose is too low, α cells in the pancreas detect this and release glucagon (the adrenal glands release adrenaline).

Glucagon (or adrenaline) combines with receptors on the cell-surface membrane of liver cells.

This activates the enzyme adenylate cyclase, which converts ATP into cyclic AMP (cAMP), the second messenger.

cAMP activates a kinase enzyme, which activates phosphorylase: glycogen is broken down to glucose (glycogenolysis).

Glucose is also made from glycerol, fatty acids and amino acids (gluconeogenesis).

20

Quality of written communication [2 marks]

END OF QUESTIONS



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