

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

Tuesday 13 June 2023

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	

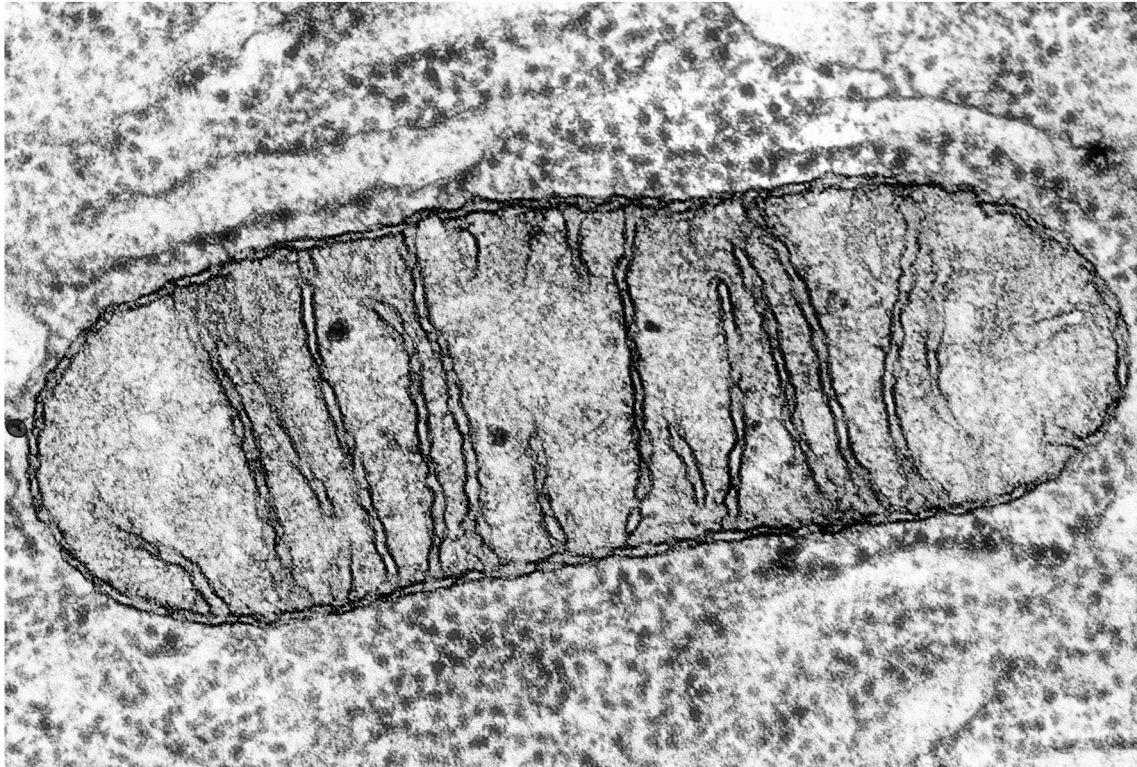


Answer **all** questions in the spaces provided.

0 1

Figure 1 shows a mitochondrion in a liver cell.

Figure 1



× 60 000

0 1

1

Name the type of microscope used for producing **Figure 1**.

[1 mark]

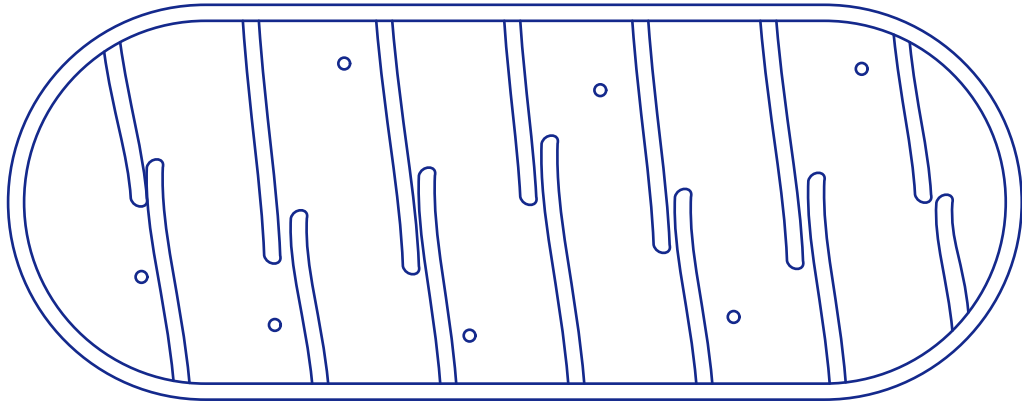
Transmission electron microscope



0 1 . 2

Draw a large, clear diagram of the mitochondrion in **Figure 1**.

[2 marks]



0 1 . 3

The magnification of **Figure 1** is $\times 60\,000$.Calculate the actual volume of the mitochondrion shown in **Figure 1**.

Assume that the mitochondrion is a cylinder.

Give your answer in μm^3 to 3 significant figures.Volume of cylinder = $\pi r^2 h$ $\pi = 3.14$

[3 marks]

length (h) on Figure 1 = 146 mm, width (diameter) = 47.5 mm *$h = 146 \div 60\,000 = 0.002433 \text{ mm} = 2.433 \mu\text{m}$* *$r = 47.5 \div 2 = 23.75 \text{ mm}$, so $r = 23.75 \div 60\,000 \text{ mm} = 0.396 \mu\text{m}$* *$V = \pi r^2 h = 3.14 \times 0.396^2 \times 2.433 = 1.198 \mu\text{m}^3$* Volume of mitochondrion = 1.20 μm^3

Question 1 continues on the next page

Turn over ►

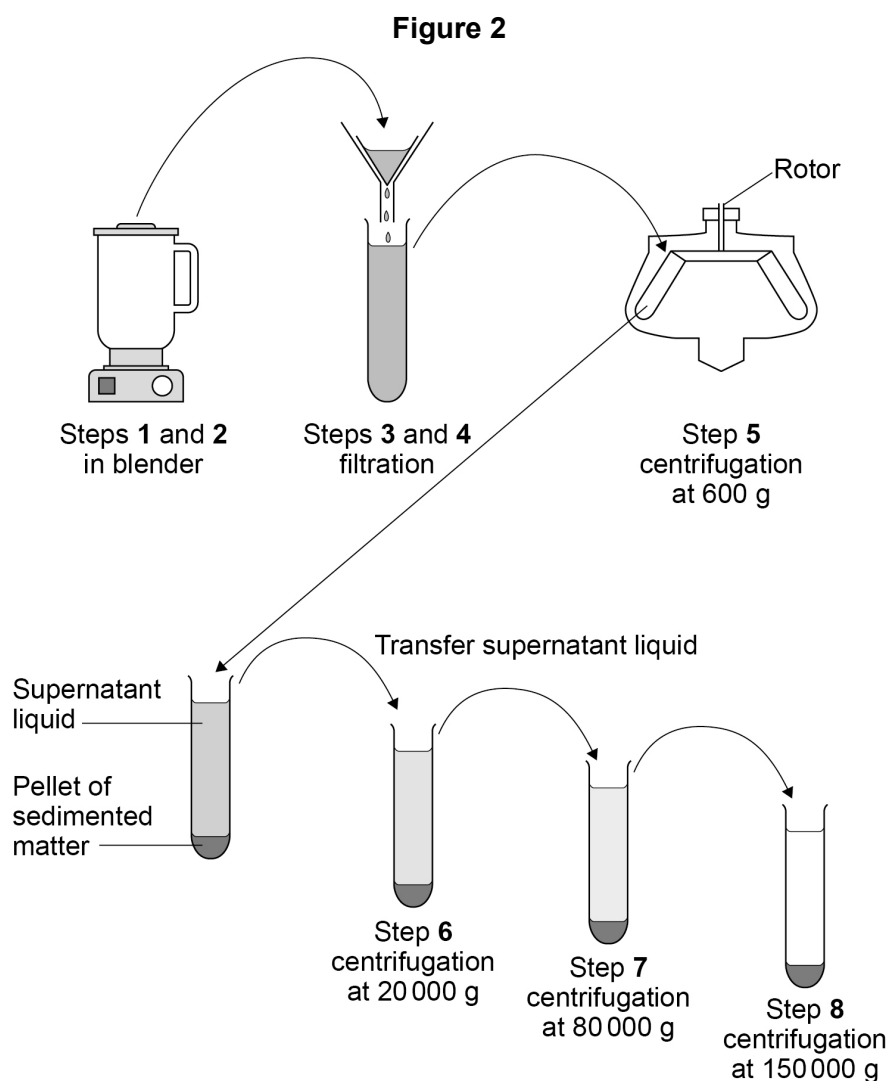


Scientists can separate mitochondria from other organelles in liver cells using the techniques of cell fractionation and ultracentrifugation.

The scientists:

1. put some liver tissue in 0.25 mol dm^{-3} sucrose solution at pH 7.4 and a temperature of 4°C
2. gently break open the liver cells in a blender
3. filter the material from the blender to remove larger pieces of cell debris
4. put the filtrate in a centrifuge tube
5. spin the centrifuge at 600 g ($600 \times$ the force of gravity) for 10 minutes
6. transfer the supernatant liquid from Step 5 to another centrifuge tube and spin at 20 000 g for 20 minutes
7. transfer the supernatant liquid from Step 6 to another centrifuge tube and spin at 80 000 g for 60 minutes
8. transfer the supernatant liquid from Step 7 to another centrifuge tube and spin at 150 000 g for 3 hours.

Figure 2 gives a summary of the scientists' method.



0 1 . 4

During the whole investigation, the scientists keep the material from the liver:

- in 0.25 mol dm^{-3} sucrose solution
- at pH 7.4
- at a temperature of 4°C .

Explain how each of these conditions prevents damage to the mitochondria.

[4 marks]

0.25 mol dm^{-3} sucrose solution *It has the same water potential as the mitochondria (isotonic), so it prevents net entry or exit of water into or out of the mitochondria by osmosis, so the mitochondria do not burst or shrink.*

pH 7.4 *Prevents denaturation of proteins / enzymes (e.g. cytochromes) in the mitochondria, as the ionic and hydrogen bonds are not broken.*

Temperature of 4°C *Slows chemical reactions: slows enzyme activity and the hydrolysis of organic substances in the mitochondria.*

0 1 . 5

Centrifugation at 80 000 g (step 7) causes sedimentation of lysosomes and pieces of membrane.

Complete **Table 1** to show which centrifugation step causes sedimentation of:

- mitochondria
- nuclei
- ribosomes.

[1 mark]

Table 1

Step	Centrifugal g-force	Organelle sedimented
5	600	<i>Nuclei</i>
6	20 000	<i>Mitochondria</i>
7	80 000	Lysosomes
8	150 000	<i>Ribosomes</i>

Question 1 continues on the next page

Turn over ►



0 1 . 6

Give the reason for your answer to Question 01.5.

[1 mark]

The heaviest / largest (most dense) organelles are sedimented first, at the lowest g-force: nuclei are the most dense, ribosomes are the least dense and mitochondria are in between.

The scientists investigate oxygen uptake by their preparation of mitochondria.

The scientists:

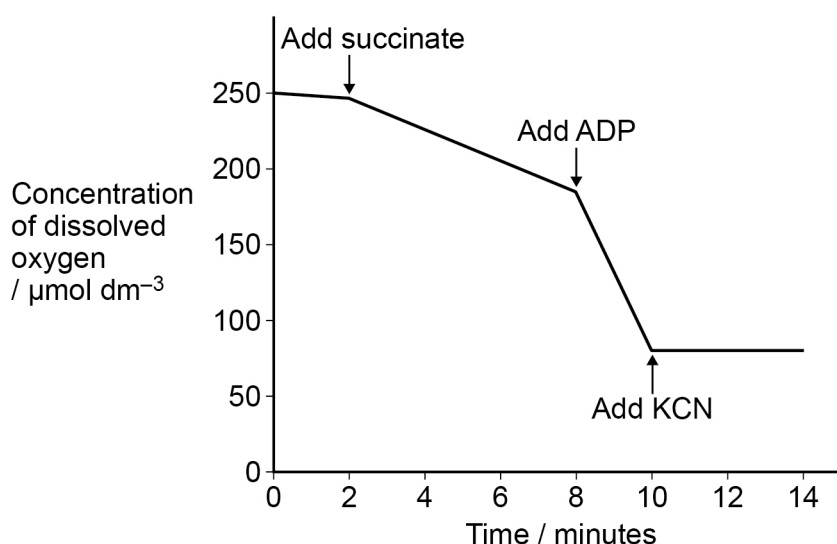
- suspend the mitochondria in 0.25 mol dm^{-3} sucrose solution at pH 7.4
- measure the concentration of dissolved oxygen in the suspension using an oxygen electrode.

The scientists test the effect of adding three substances, in sequence, to the suspension of mitochondria:

1. succinate – a substrate of the Krebs cycle
2. ADP
3. potassium cyanide (KCN) – binds to cytochrome oxidase and inhibits the final step in the electron transfer chain.

Figure 3 shows the scientists' results.

Figure 3



0 1 . 7

Explain why adding succinate causes a decrease in the concentration of dissolved oxygen.

[2 marks]

Succinate is oxidised in the Krebs cycle, producing reduced coenzyme (reduced FAD / reduced NAD).

The reduced coenzyme passes electrons and hydrogen down the electron transfer chain to oxygen, the final electron acceptor, converting oxygen to water, so oxygen is used up.

0 1 . 8

Explain why adding ADP causes a decrease in the concentration of dissolved oxygen.

[2 marks]

The ADP is converted to ATP in the electron transfer chain, by oxidative phosphorylation (ADP + Pi).

So electrons and hydrogen pass down the chain faster to oxygen, the final electron acceptor, and more oxygen is reduced to water.

0 1 . 9

Potassium cyanide (KCN) is poisonous.

Use information from **Figure 3** to explain why.

[3 marks]

Figure 3 shows the oxygen concentration stays constant ($80 \mu\text{mol dm}^{-3}$) after KCN is added, so oxygen is no longer used: electrons / hydrogen are not transferred to oxygen.

So no ATP is produced by oxidative phosphorylation, and NAD / FAD are not regenerated for glycolysis and the Krebs cycle.

So little or no usable energy is released for metabolism, and cells die.

19

Turn over for the next question

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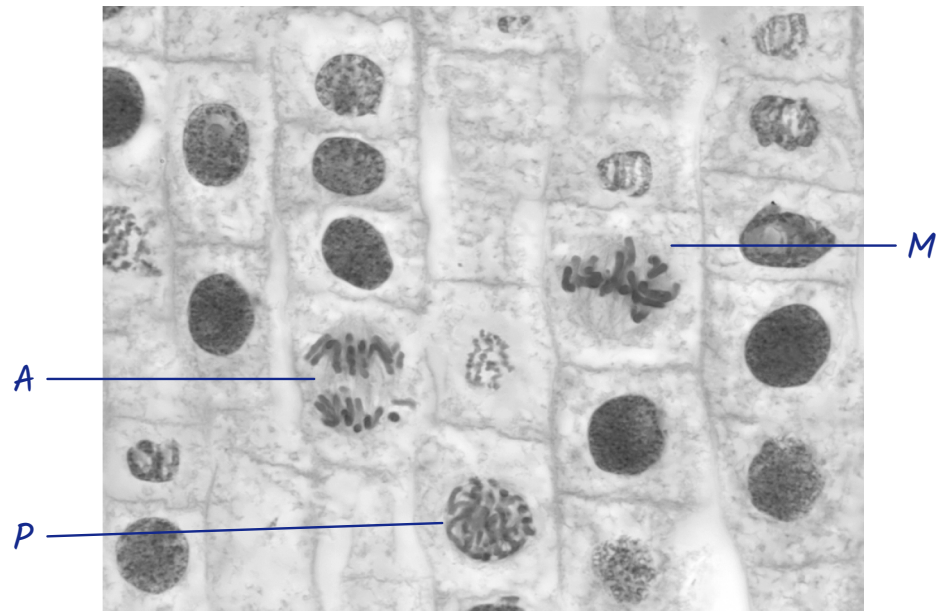


0 2

In eukaryotic organisms, cells divide by mitosis during growth.

Figure 4 shows cells from the root of an onion plant.

Figure 4



0 2

1

Write each of the letters **A**, **M** and **P** on **Figure 4** to label the following:

- A** one cell in anaphase
- M** one cell in metaphase
- P** one cell in prophase.

[3 marks]



0 2 . 2

Describe how you would prepare a slide to show cells from an onion root similar to those in **Figure 4**.

[5 marks]

Cut off the end of an onion root and place it in hot hydrochloric acid (e.g. 1 mol dm^{-3} at 60°C for 5 minutes) to fix it, then wash it in water.

Cut off the tip of the root (the end 2 to 5 mm) and place it on a clean microscope slide.

Add a few drops of stain, e.g. toluidine blue or aceto-orcein, to stain the chromosomes.

Break up (macerate) the tissue with a mounted needle to spread the cells out.

Place a coverslip on top and squash it firmly (press down through filter paper) to give a single layer of cells, and blot off the excess stain from outside the coverslip.

Observe under a light microscope, first at low power and then at high power.

Question 2 continues on the next page

Turn over ►



A class of 10 students prepares slides from onion roots.

The students count the number of cells in each of the different phases of mitosis.

Table 2 shows the results.

Table 2

Phase	Students										Class total
	1	2	3	4	5	6	7	8	9	10	
Interphase	149	160	121	135	166	232	155	164	162	113	1557
Prophase	35	25	21	30	19	10	15	24	20	16	215
Metaphase	20	12	18	9	11	6	20	12	7	11	126
Anaphase	4	8	5	14	4	0	11	12	8	3	69
Telophase	9	6	14	11	8	4	7	8	12	12	91
Total cells	217	211	179	199	208	252	208	220	209	155	2058
Cells in mitosis	68	51	58	64	42	20	53	56	47	42	501
Mitotic index	0.31	0.24	0.32	0.32	0.20	0.08	0.25	0.25	0.22	0.27	X

0 2 . 3

Calculate the mitotic index, **X**, for the results from the whole class.

Use data from the **Class total** column in **Table 2**.

Give your answer to an appropriate level of accuracy.

[1 mark]

$$\begin{aligned}\text{mitotic index} &= \text{cells in mitosis} \div \text{total cells} \\ &= 501 \div 2058 = 0.2434\end{aligned}$$

Mitotic index for results from whole class = 0.24



The students calculate the standard deviation (SD) of the mitotic indices from their 10 sets of results:

$$SD = 0.07$$

The teacher states:

‘There is a significant error in the results from student 6.’

0 2 . 4

Use data from **Table 2** and your answer to Question **02.3** to explain the teacher’s statement.

[2 marks]

Student 6’s mitotic index (0.08) is more than 2 SD below the class value: $0.24 - (2 \times 0.07) = 0.10$, and $0.08 < 0.10$.

We expect 95% of values to lie within the mean ± 2 SD, so a value this far away would occur by chance in less than 5% of cases; the difference is significant.

0 2 . 5

Student **6** made a mistake while preparing his slide.

Suggest what mistake student **6** made.

Use information from **Table 2** to give the reason for your answer.

[2 marks]

Mistake *Cells were taken from a region too far from the root tip, not from the meristem (region of cell division).*

Reason *A high proportion of the cells are in interphase (232 out of 252), so a low proportion are in mitosis (only 20, with none in anaphase).*

13

Turn over for the next question

Turn over ►



0 3

Genes often have several alleles.

An allele may be dominant, recessive or codominant.

0 3

1

Explain how a **codominant** allele is different from a **dominant** allele.

Use **all** the words from the box in your answer.

genotype

heterozygous

homozygous

phenotype

[2 marks]

A codominant allele is expressed in the phenotype in the homozygous genotype, and in the heterozygous genotype both alleles are expressed in the phenotype (neither allele masks the other).

A dominant allele is expressed in the phenotype in both the homozygous genotype and the heterozygous genotype (it masks the recessive allele).



The human **ABO** blood group system is an example of a characteristic controlled by multiple alleles. The alleles show a mixture of being dominant, codominant and recessive.

A person can have one of four possible blood groups:

group **A**

group **B**

group **AB**

group **O**

The blood group is determined by the inheritance of three different alleles:

I^A = allele for blood group **A**

I^B = allele for blood group **B**

I^O = allele for blood group **O**

0 3 . 2

A man with blood group **A** and a woman with blood group **B** have two children:

a child with blood group **O**

a child with blood group **AB**

Complete the genetic diagram in **Figure 5** to explain how the children can inherit different blood groups.

You should include **all** possible offspring genotypes and phenotypes in your answer.

[4 marks]

Figure 5

	Man		Woman																
Parental phenotypes	Group A		Group B																
Parental genotypes	$I^A I^O$		$I^B I^O$																
Genotypes of gametes	I^A	I^O	I^B	I^O															
	<table border="1"> <tr> <td>woman → man ↓</td><td>I^B</td><td>I^O</td><td></td><td></td></tr> <tr> <td>I^A</td><td>$I^A I^B$ group AB</td><td>$I^A I^O$ group A</td><td></td><td></td></tr> <tr> <td>I^O</td><td>$I^B I^O$ group B</td><td>$I^O I^O$ group O</td><td></td><td></td></tr> </table>				woman → man ↓	I^B	I^O			I^A	$I^A I^B$ group AB	$I^A I^O$ group A			I^O	$I^B I^O$ group B	$I^O I^O$ group O		
woman → man ↓	I^B	I^O																	
I^A	$I^A I^B$ group AB	$I^A I^O$ group A																	
I^O	$I^B I^O$ group B	$I^O I^O$ group O																	
Offspring genotypes	$I^A I^B$	$I^A I^O$	$I^B I^O$	$I^O I^O$															
Offspring phenotypes	AB	A	B	O															

6

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0 4

Farmers can spray crop plants with hormones to control the growth of the plants.

Scientists investigate the effect of a plant growth hormone called GA₃ on the growth of avocado fruits.

The scientists:

1. spray 10 avocado trees with a solution of GA₃
2. spray 10 more avocado trees with water as a control
3. take two fruits from each tree at intervals for 135 days
4. remove a 10 g sample of flesh from each of the fruits
5. determine the dry mass of each sample
6. calculate the dry mass as a percentage of each sample.

0 4 . 1

Describe how the scientists could determine the dry mass of each sample (step 5).

[2 marks]

Heat each sample in an oven at about 100 °C (between 95 °C and 105 °C) to evaporate the water.

Weigh, then reheat and reweigh repeatedly until the mass is constant (all water removed).

Question 4 continues on the next page

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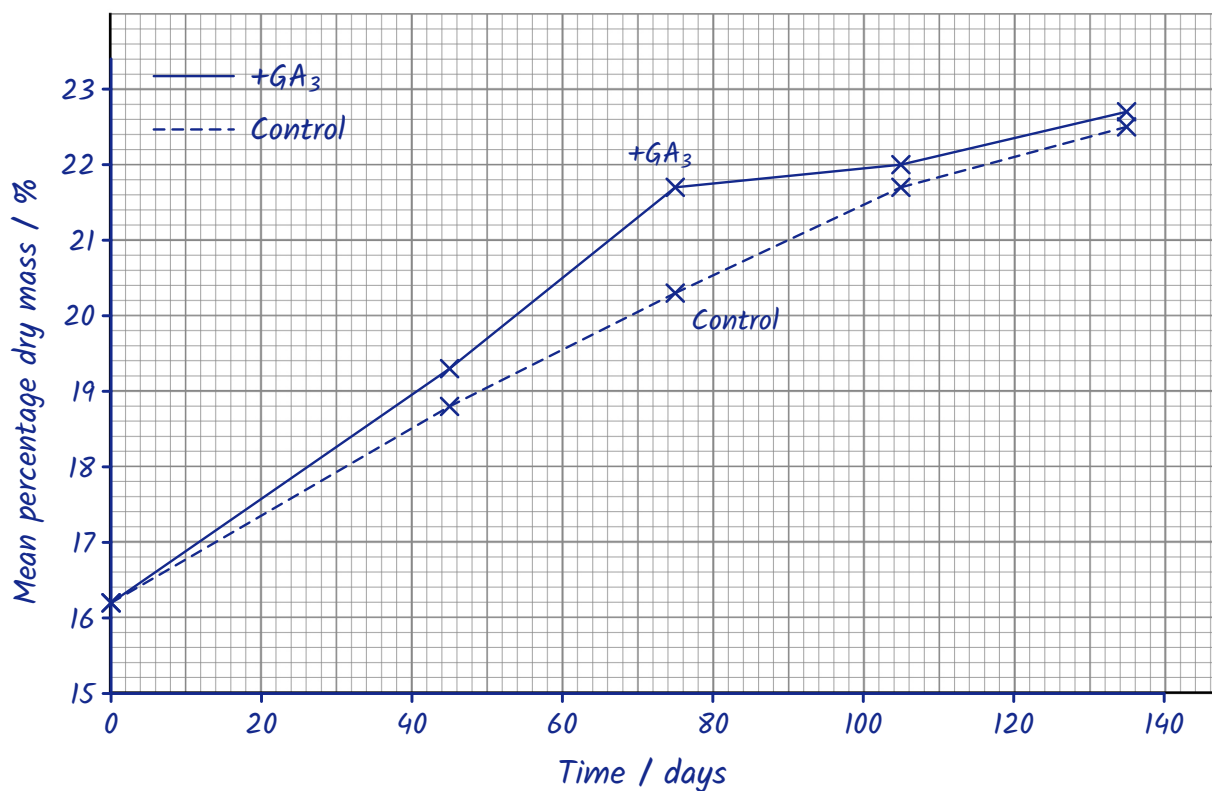
Table 3 shows the scientists' results.

Table 3

Time / days	Mean percentage dry mass of avocado flesh	
	+GA ₃	Control
0	16.2	16.2
45	19.3	18.8
75	21.7	20.3
105	22.0	21.7
135	22.7	22.5

0 4 . 2 Plot a graph of the data in **Table 3**.

[4 marks]



0 4 . 3

During the first 75 days, the avocado fruits grew faster on the GA₃-sprayed trees than on the control trees.

Calculate the percentage increase in growth rate of the fruits sprayed with GA₃ compared with the growth rate of the control fruits during the first 75 days.

Give your answer to 3 significant figures.

[2 marks]

$$\text{rate (+GA}_3\text{)} = (21.7 - 16.2) \div 75 = 5.5 \div 75 = 0.0733 \text{ \% per day}$$

$$\text{rate (control)} = (20.3 - 16.2) \div 75 = 4.1 \div 75 = 0.0547 \text{ \% per day}$$

$$\text{\% increase} = (5.5 - 4.1) \div 4.1 \times 100 = 34.146$$

Percentage increase in growth rate = 34.1 %

0 4 . 4

Avocado fruits are mature when they contain at least 21.5% dry matter.

A farmer looked at the scientists' data.

Suggest why the farmer decides to spray some avocado trees with GA₃ and to leave some trees unsprayed.

Use data from your graph in Question 04.2 in your answer.

[2 marks]

From my graph, the GA₃-sprayed fruits reach 21.5% dry matter

(maturity) at about 72 days but the control fruits only at about 100

days: 28 days later.

So spraying only some trees prolongs the harvesting season: fruit can be picked and sold over a longer period, increasing sales and profits.

10

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0 5

Omega-3 and omega-6 are two types of unsaturated fatty acid.

Doctors think that a diet with a high ratio of omega-3 to omega-6 fatty acid is good for human health.

Scientists are investigating how to produce meat from sheep that contains a higher proportion of omega-3 fatty acids.

Three different methods are being used:

- selective breeding
- adding fish oils to the diet of the sheep
- genetic engineering.

0 5 . 1

Suggest how selective breeding could be used to increase the proportion of omega-3 in sheep.

[2 marks]

Select the sheep with the highest omega-3 : omega-6 ratio (highest omega-3) in their meat and only mate (breed) these together.

Repeat with the offspring over many subsequent generations, each time selecting those with the highest ratio.

0 5 . 2

Suggest **one** reason why feeding sheep with fish oils containing a high omega-3 concentration may **not** affect the ratio of omega-3 to omega-6 fatty acids in meat from sheep.

[1 mark]

The ingested omega-3 may be altered by the sheep's metabolism or used in respiration, so it may not enter the muscle (meat).

Question 5 continues on the next page

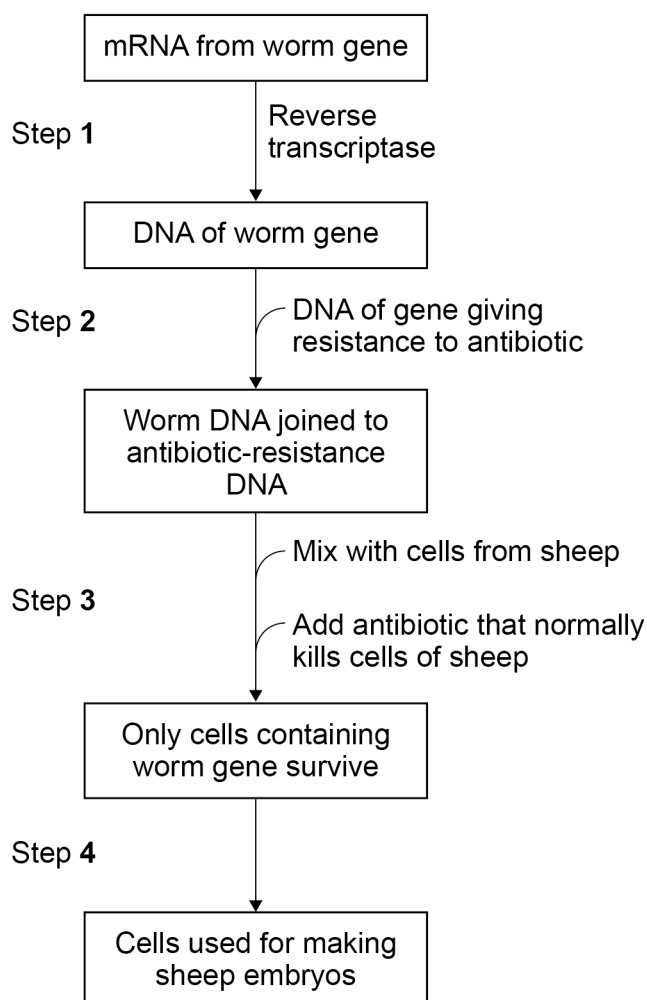
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Scientists have produced genetically-modified sheep containing a gene from a worm. This gene codes for an enzyme that changes omega-6 fatty acids into omega-3 fatty acids.

Figure 6 shows the method used for producing the genetically-modified sheep.

Figure 6



0 5 . 3

Give **two** advantages of using mRNA to make the worm gene at step 1, instead of using a restriction enzyme to cut the gene from the worm's DNA.

[2 marks]

1 *There is more mRNA for the gene in the cell (many copies) than DNA (only two copies of the gene), so it is easier to obtain.*

2 *Introns (non-coding bases) have been removed from mRNA by splicing, so the DNA made has only exons; the mRNA is also specific to the desired gene.*

0 5 . 4

Explain why a gene giving resistance to an antibiotic is attached to the DNA at step 2.

[2 marks]

Cells that have been successfully genetically modified (contain the worm gene) also contain the resistance gene, so it is a marker to select which cells have been modified.

When the antibiotic is added, only the GM cells survive; cells without the gene are killed.

7

Turn over for the next question

Turn over ►



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

0 6

Carbohydrates are important to all living organisms.

0 6 . 1

Ribose is a pentose sugar.

Ribose is a component of adenosine triphosphate (ATP).

Describe the structure and the function of ATP in living cells.

[6 marks]

ATP is a nucleotide derivative made of the base adenine joined to the pentose sugar ribose, which is joined to a chain of three phosphate groups: adenine-ribose-phosphate-phosphate-phosphate.

ATP is hydrolysed by ATP hydrolase to ADP and inorganic phosphate (Pi), releasing energy; it is the immediate energy source of the cell.

Functions:

Active transport, e.g. uptake of mineral ions into plant roots, Na⁺ and K⁺ pumping in neurones, H⁺ ions for stomatal opening, and absorption of glucose and amino acids from the small intestine.

Protein synthesis: forming peptide bonds to join amino acids.

Synthesis of other organic molecules, e.g. DNA, RNA and acetylcholine.

Light-independent reaction of photosynthesis: converting GP to triose phosphate (TP).

Phosphorylation (activation) of glucose at the start of glycolysis.

Muscle contraction: to move the myosin heads and to re-set the cross-bridges.

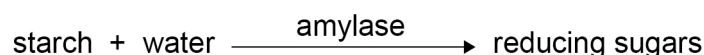
Mitosis and meiosis: movement of the chromosomes; hormone action: formation of cyclic AMP.



0 6 . 2

Starch is a polysaccharide made by plants.

The enzyme amylase catalyses the reaction:



Describe how you could investigate the effect of temperature on the activity of amylase.

[6 marks]

Use the same volume and concentration of starch suspension (e.g. 5 cm³ of 1%) and of amylase solution (e.g. 1 cm³) each time, measured with syringes.

Add the same volume of pH buffer solution at the optimum pH.

Use water baths to keep a range of at least five temperatures between 0 °C and 80 °C, e.g. 10, 20, 30, 40, 50 and 60 °C.

Pre-incubate the starch and the amylase in separate tubes in the water bath at T °C for 5 minutes.

Mix the starch and amylase, start a stopwatch and return the tube to the water bath at T °C.

Every 30 seconds remove a drop of the mixture and test it with iodine solution (iodine-KI) on a spotting tile.

Record the time taken until the iodine stays yellow-brown (not blue-black), when all the starch is hydrolysed; rate = 1 ÷ time.

Repeat three times at each temperature and calculate a mean.

Repeat at smaller intervals around the temperature with the shortest time.

Question 6 continues on the next page

Turn over ►



0 6 . 3

Describe how different types of carbohydrate are used by living organisms.

[6 marks]

Glucose is a source of energy: it is broken down in respiration to release energy to make ATP.

Starch (in plants) and glycogen (in animals) store glucose / energy: they are large, insoluble and compact, and branched so glucose is released quickly by hydrolysis.

Cellulose forms plant cell walls for support and protection; peptidoglycan (murein) forms bacterial cell walls for support and protection.

Glycoproteins and glycolipids on cell-surface membranes are used in cell recognition and as hormone binding sites; antibodies are glycoproteins used in the immune response to pathogens.

Ribose in RNA and deoxyribose in DNA: genes and gene expression.

Sucrose is small and soluble, so it is transported in the phloem of plants; sucrose in nectar attracts insects for pollination.

Lactose in milk is a source of energy (via respiration) for young mammals; blood glucose maintains the water potential of the blood.

20

Quality of written communication [2 marks]**END OF QUESTIONS**

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