

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

Monday 20 January 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 A N 2 5 B L O 5 0 1

0 1

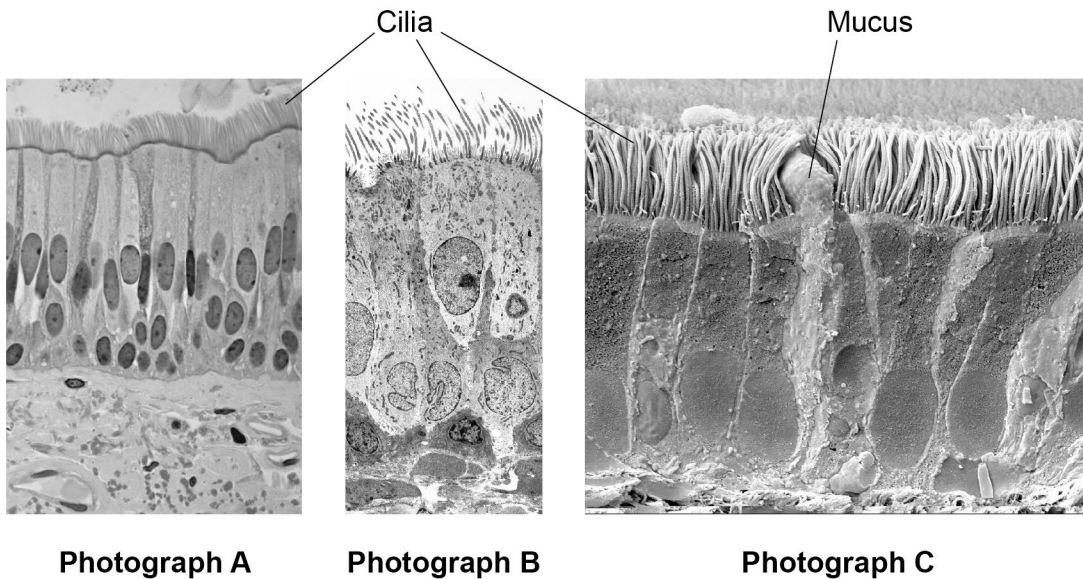
The trachea takes air to and from the lungs.

The trachea also helps to keep microorganisms out of the lungs.

Figure 1 shows cells that form the inner lining of the human trachea.

Most of the cells have tiny extensions, called 'cilia' (singular 'cilium'). The cilia are at the surface of the cells, in contact with the air in the trachea. Some cells in the lining of the trachea secrete a sticky substance called 'mucus'.

Figure 1



0 1 . 1

Photographs **A**, **B** and **C** in **Figure 1** were made using different types of microscope.

Name the type of microscope used for making each photograph.

[3 marks]

A Light (optical) microscope

B Transmission electron microscope (TEM)

C Scanning electron microscope (SEM)



0 1 . 2

Photograph B shows the structure of the cells in more detail than **Photograph A**.

Explain why.

[2 marks]

Photograph B was made with an electron microscope. Electrons have a shorter wavelength than light (used for Photograph A).

So B has a higher resolution than A: it can distinguish between two objects that are closer together, so more detail is seen.

0 1 . 3

Each cilium in **Photograph C** appears as a continuous, 3-dimensional structure.

Many of the cilia in **Photograph B** do **not** appear to be continuous.

Suggest why some cilia in **Photograph B** do **not** appear as continuous structures.

[2 marks]

Photograph B is a thin section cut through the cells.

Many cilia are curved, so they are not entirely within the plane of the section; only parts of them are cut, so they look broken.

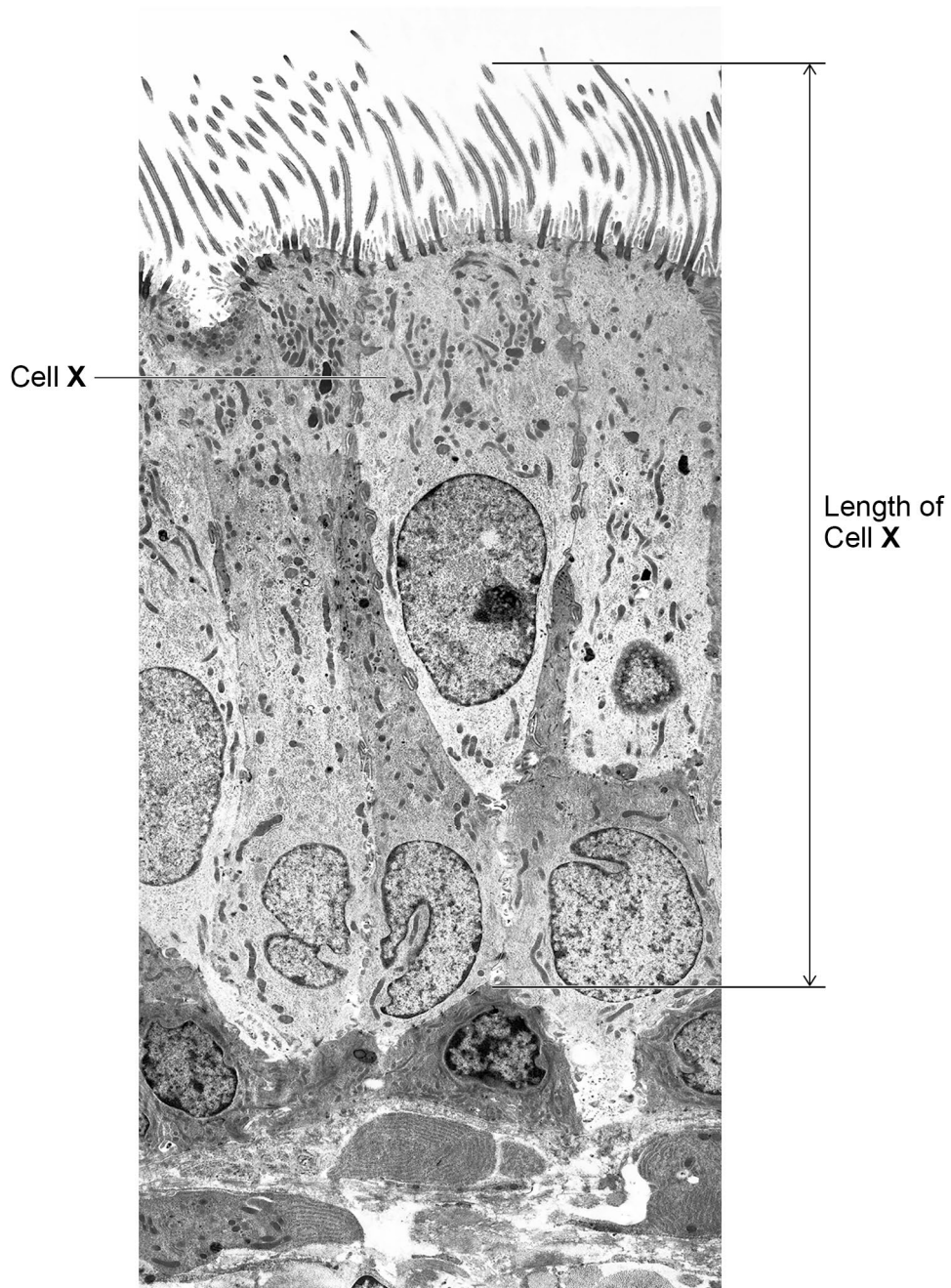
Question 1 continues on the next page

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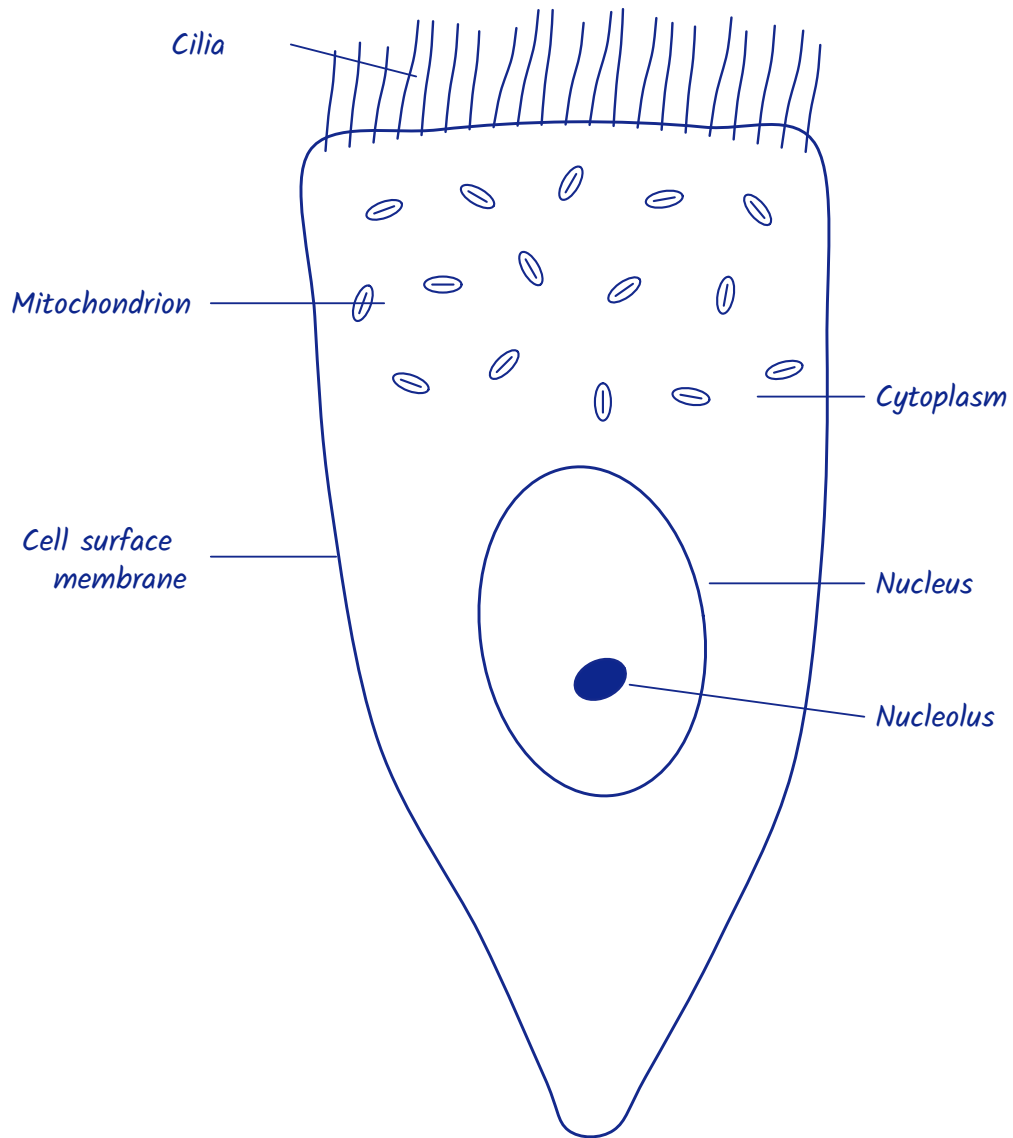
Figure 2 shows **Photograph B** from **Figure 1** (on page 2) at a higher magnification.

Figure 2



0 1 . 4 Draw a large, clear diagram of cell X in **Figure 2**.

[3 marks]



Question 1 continues on the next page

Turn over ►



0 1 . 5

The real length of cell **X** is 60 μm Calculate the magnification of **Figure 2** (on page 4).Give your answer to **3** significant figures.**[3 marks]**

$$\text{length of cell X in Figure 2} = 125 \text{ mm} = 125\,000 \mu\text{m}$$

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

$$= 125\,000 \mu\text{m} \div 60 \mu\text{m} = 2083.3$$

$$= 2080 \text{ (3 s.f.)}$$

$$\text{Magnification} = \underline{\quad \times 2080 \quad}$$



Question 1 continues on the next page

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0 7

0 1 . 6 **Photograph C** in **Figure 1** (on page 2) shows some mucus-secreting cells.

Mucus is a sticky substance.

Microorganisms can be trapped in this mucus.

The cilia beat and move the mucus up the trachea, away from the lungs.

Scientists investigate the effect of smoke from cigarettes on cilia in the human trachea and in the tracheas of mice.

Figure 3 shows the results for the human investigation.

Figure 4 shows the results for the mouse investigation.

The error bars show $\pm$ standard errors.

Figure 3

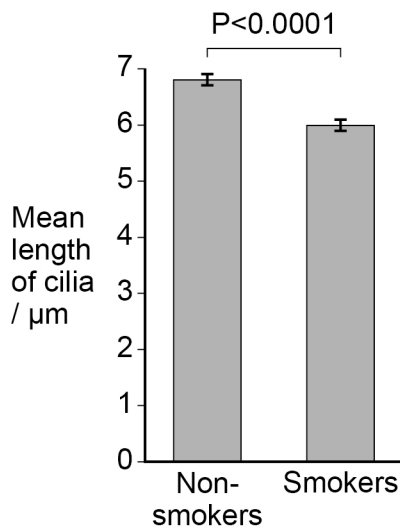
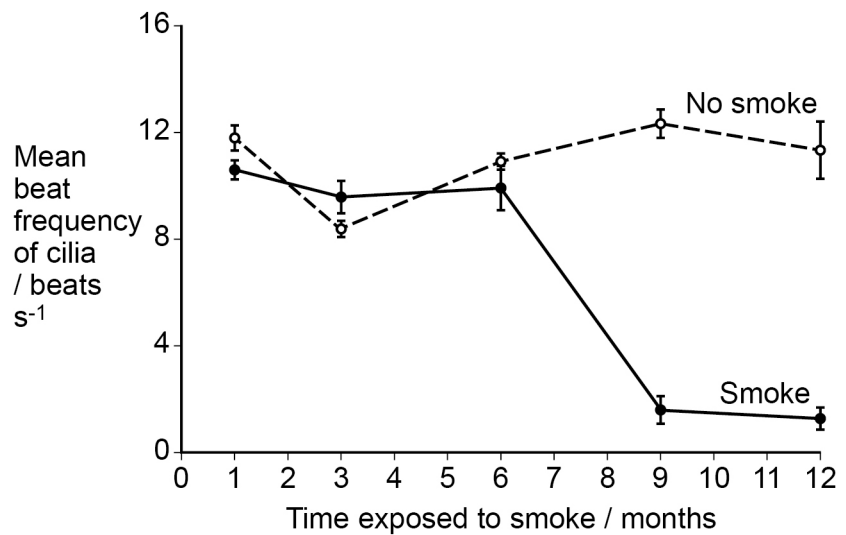


Figure 4



Suggest why people who smoke cigarettes (smokers) are more likely to have lung infections than people who do not smoke cigarettes (non-smokers).

Use information from **Figure 3** and **Figure 4**, and information given earlier in Question **01**.

[4 marks]

Figure 3: the cilia of smokers are significantly shorter than those of non-smokers ($P < 0.0001$), about $6.0 \mu\text{m}$ compared with $6.8 \mu\text{m}$.

Figure 4: after 9 months of smoke exposure the cilia beat at a significantly lower rate (frequency), about 1.5 beats s^{-1} compared with 12 beats s^{-1} with no smoke; the error bars do not overlap.

So shorter cilia beating more slowly make it more difficult to move (remove) the mucus up the trachea, away from the airways and lungs.

So microorganisms trapped in the mucus remain in, or can reach, the lungs, where they can cause infections (disease).

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Turn over for the next question

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0 2

Students investigate the effect of temperature on the rate of photosynthesis in plants.

The students use the pondweed *Elodea* in their investigation.

Figure 5 shows the equipment the students use.

Figure 5

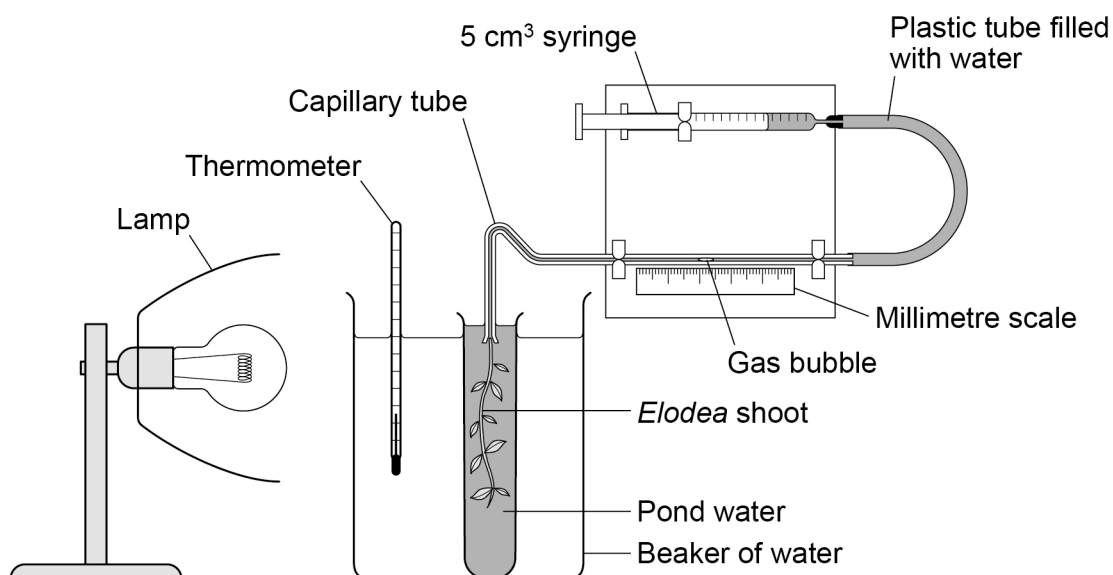


Table 1 shows the students' results.

Table 1

Temperature / °C	Mean rate of oxygen production ± SD / mm ³ min ⁻¹
0	0.2 ± 0.1
10	4.3 ± 2.7
20	16.2 ± 8.0
30	32.3 ± 6.4
35	35.8 ± 3.5
40	17.7 ± 8.2
50	3.2 ± 2.3



0 2 . 1

Describe, in detail, how the students could use the equipment shown in **Figure 5** to obtain the results shown in **Table 1**.

[7 marks]

At each temperature (0, 10, 20, 30, 35, 40 and 50 °C), set the beaker of water to that temperature and keep it constant during each set of readings, checking with the thermometer.

Keep the lamp at a constant distance, e.g. 10 cm, and the CO₂ concentration the same by adding the same concentration of NaHCO₃ solution.

Leave the Elodea in the apparatus at each temperature to equilibrate for at least 5 minutes.

Collect the gas (oxygen) for a set time, e.g. 5 minutes.

Use the syringe to pull the gas bubble along the capillary tube onto the millimetre scale and measure the length of the gas bubble in millimetres.

Convert the length to a volume in mm³ using $\pi r^2 l$, where r is the radius of the capillary tube bore.

Convert to a rate (mm³ min⁻¹) by dividing by the time taken.

Repeat at least 3 times at each temperature and calculate the mean rate and the standard deviation.

Question 2 continues on the next page

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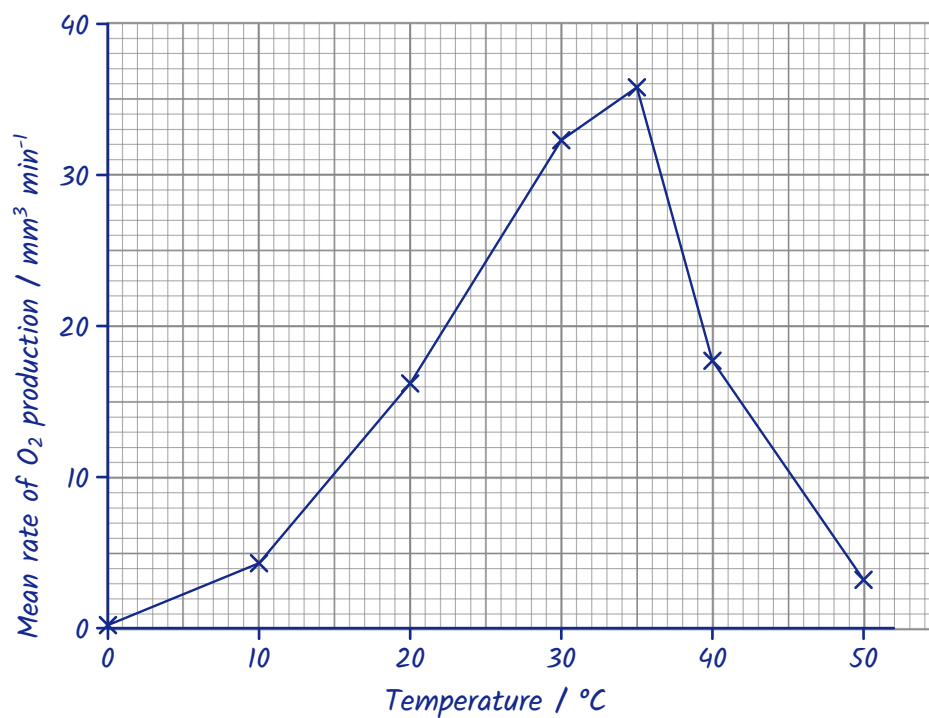
0 2 . 2 Plot a graph of the results shown in **Table 1**.

Do **not** include SD bars on your graph.

[4 marks]

Repeat of Table 1

Temperature / °C	Mean rate of oxygen production $\pm$ SD / mm ³ min ⁻¹
0	0.2 $\pm$ 0.1
10	4.3 $\pm$ 2.7
20	16.2 $\pm$ 8.0
30	32.3 $\pm$ 6.4
35	35.8 $\pm$ 3.5
40	17.7 $\pm$ 8.2
50	3.2 $\pm$ 2.3



0 2 . 3 Which temperature gives the most variation in results?

Give the evidence for your answer.

[1 mark]

Temperature 40 °C

Evidence It has the largest standard deviation ($\pm 8.2 \text{ mm}^3 \text{ min}^{-1}$).

0 2 . 4 One student states:

‘The optimum temperature for photosynthesis in plants is 35 °C.’

The teacher says this conclusion is **not** correct.

How could the students change their investigation to improve this conclusion?

[3 marks]

Do more readings at smaller temperature intervals, e.g. every 1 or 2 °C,
both sides of and near to 35 °C (between 30 and 40 °C).

Do more repetitions at each temperature, and re-plot the graph, including
the new data, on a larger scale.

Test with different species of plant, as the conclusion is about all
plants, not just Elodea.

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Turn over for the next question

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0 3

Students investigate the effect of exercise on heart rate.

Each student:

- counts their pulse for 10 seconds while at rest
- multiplies the pulse count by 6 to find their heart rate in beats per minute
- is given the instruction to exercise for 0.5 minute and to count their pulse again for 10 seconds
- immediately repeats the exercise for 1 minute and for 2 minutes.

Table 2 shows the results.

Table 2

Length of exercise / minutes	Heart rate / beats per minute		
	Student 1	Student 2	Student 3
0	72	78	60
0.5	90	84	96
1.0	96	90	120
2.0	108	96	132

0 3 . 1

The students count their pulse rates for 10 seconds. They multiply the value by 6 to find the heart rate per minute.

Suggest **one** advantage and **one** disadvantage of measuring the pulse rates for 10 seconds.

[2 marks]

Advantage *Less time is taken, so there is less time for recovery; the heart rate would not slow down during the count.*

Disadvantage *Any error in counting is multiplied by 6; an error of 1 beat in 10 s becomes an error of 6 beats per minute.*



0 3 . 2

Each student 'is given the instruction to exercise' for the stated times.

Suggest how this instruction could be improved to give more valid results.

[1 mark]

Standardise the intensity and type of exercise, e.g. all do step-ups at the same rate, such as 1 step s^{-1} , onto the same height of step.

0 3 . 3

Suggest **two** other improvements to the students' method.

[2 marks]

1 *Increase the sample size, e.g. use more students or do repetitions with the same students and calculate a mean.*

2 *Allow time for the heart rate to recover to the resting rate between one round of exercise and the next.*

5

Turn over for the next question

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0 4

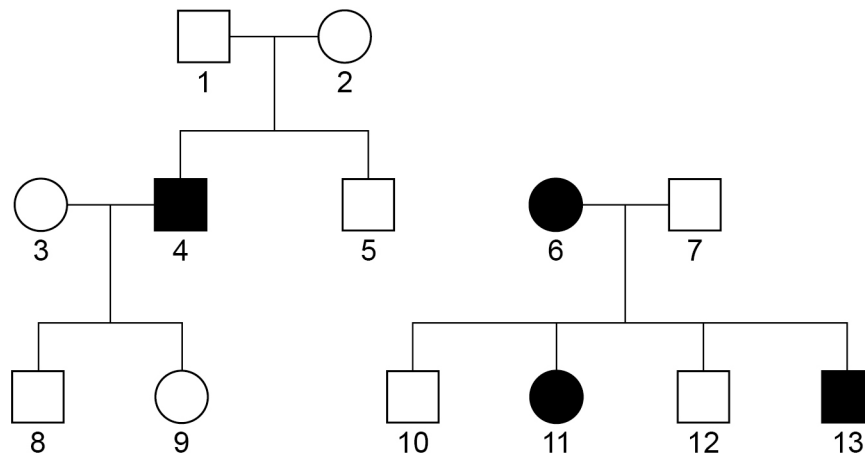
Phenylketonuria (PKU) is a genetic disorder.

If untreated, PKU causes brain and nerve damage.

PKU is caused by a recessive allele.

Figure 6 shows the inheritance of PKU in two families.

Figure 6



Key

- = male with PKU
- = male without PKU
- = female with PKU
- = female without PKU

In this question, use the following symbols for alleles.

N = allele for **not** having PKU

n = allele for having PKU

0 4 . 1

Give evidence from **Figure 6** to show that the allele for PKU is recessive.

[1 mark]

Two unaffected parents, 1 and 2, have a child (4) with PKU.



0 4 . 2 What are the genotypes of individuals **1** and **2**?

[1 mark]

1 Nn

2 Nn

0 4 . 3 Individuals **9** and **10** get married and plan to start a family.

Draw a genetic diagram to find the probability that their first child will have PKU.

[4 marks]

Phenotypes of parents: no PKU (9) no PKU (10)

Parental genotypes: Nn × Nn

Gametes: N n N n

	N	n
N	NN	Nn
n	Nn	nn

Offspring genotypes: NN Nn Nn nn

Offspring phenotypes: non-PKU (3) PKU (1)

Probability of PKU = 1 in 4

Probability = 0.25

Question 4 continues on the next page

Turn over ►



In one country, 1 in 2600 people has PKU.

The population of the country is 86 171 873

0 4 . 4

A student uses the Hardy–Weinberg equation to estimate the number of people in this country that do **not** have the allele for PKU in their genotype.

What answer should the student get?

[3 marks]

$$q^2 = 1 \div 2600 = 0.0003846$$

$$q = \sqrt{0.0003846} = 0.0196$$

$$p = 1 - q = 1 - 0.0196 = 0.9804$$

people without the PKU allele = NN, so frequency = p^2

$$p^2 = 0.9804^2 = 0.9612$$

$$\text{number} = 0.9612 \times 86\,171\,873 = 82\,828\,404$$

Number of people = 82 828 404

0 4 . 5

The use of the Hardy–Weinberg equation may **not** be appropriate in this situation.

Give **three** reasons why.

[3 marks]

1 There is selection against PKU (nn): some people with PKU may not survive or reproduce.

2 Mating is not random, e.g. people may choose partners from the same family or group.

3 The population is not isolated: there is immigration and emigration (or mutation may occur).



0 5

The control of blood glucose concentration depends on changing glucose into glycogen and changing glycogen into glucose.

0 5**1**

Name **two** organs that store large amounts of glycogen.

[2 marks]

1 *Liver*

2 *Muscle (skeletal muscle, e.g. biceps)*

People with Type 2 diabetes often have a high concentration of glucose in their blood.

Scientists investigate the effect of a new drug called Tirzepatide on blood glucose concentration. Tirzepatide acts in the same way as naturally-occurring hormones that are released by the gut after a meal. These hormones stimulate the release of insulin from the pancreas and inhibit the release of glucagon.

0 5**2**

Give the reason why it is important to inhibit the release of glucagon after a meal.

[1 mark]

Glucagon causes glycogen to be converted to glucose, so its release

would increase the blood glucose concentration, which is already

increased after a meal.

Question 5 continues on the next page

Turn over ►

The scientists work in India, Japan, Mexico and the USA, in 52 different medical research centres.

The scientists use a computer program to put 478 patients with Type 2 diabetes randomly into two groups. The two groups each have both men and women from a variety of ethnic groups, aged between 50 and 60.

In one of the groups, the patients are injected with Tirzepatide once a week for 40 weeks. Patients in the other group are injected each week with a placebo (a solution with no Tirzepatide).

The study is double-blind. This means that the scientists and the patients do not know who is in each group.

The scientists take blood samples from each patient at intervals during the 40 weeks of the investigation. The scientists measure the concentration of a substance called HbA1c in the blood samples. HbA1c is a compound of glucose and haemoglobin in the red blood cells.

The scientists calculate mean values for the placebo group and mean values for the group given Tirzepatide.

Figure 7 shows the scientists' results.

The error bars show $\pm$ standard errors.

Figure 7

Figure cannot be reproduced here due to third-party copyright restrictions

The graph is taken from the following article:

Efficacy and safety of a novel dual GIP and GLP-1 receptor agonist tirzepatide in patients with type 2 diabetes (SURPASS-1): a double-blind, randomised, phase 3 trial by *Julio Rosenstock et al, Lancet* 2021; 398: 143–55

Published Online June 26, 2021

[https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(21\)01324-6/abstract](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)01324-6/abstract)



0 5 . 3

Give the reason why each of the following increases the validity of the scientists' investigation.

[2 marks]

Using 478 patients *A large number reduces the effect of anomalies (outliers), so a more reliable and representative mean can be calculated.*

Using a double-blind trial *It overcomes bias (expectation) of the doctors and the patients, so doctors cannot treat the patients differently and there are no psychological (placebo) effects.*

0 5 . 4

The scientists calculated that the results for Tirzepatide at 40 weeks gave $P < 0.0001$ compared with the placebo.

State the meaning of $P < 0.0001$

[1 mark]

There is less than 0.01% probability that the difference between Tirzepatide and the placebo is due to chance (> 99.99% probability it is not), so the difference is significant.

6

Turn over for the next question

Turn over ►



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

0 6

Proteins are found in all living organisms.

0 6 . 1

Describe the different ways that proteins are used in the human body.

[6 marks]

Enzymes: proteins are specific catalysts for all metabolic reactions, e.g.

amylase hydrolyses starch; ATP synthase in the inner mitochondrial

membrane makes ATP from ADP and P_i .

Structural proteins: collagen in tendons (fibrous and inelastic), elastic

fibres in ligaments, proteins in cell surface membranes and membranes

of organelles, and in ribosomes.

Movement: actin and myosin in muscle contraction; spindle fibres

(microtubules) move chromosomes in mitosis and meiosis.

Transport across membranes: channel proteins such as aquaporins and

Na^+ and K^+ ion channels in neurones; carrier proteins in facilitated

diffusion, co-transport (Na^+ and glucose) and active transport (Na^+/K^+

ATPase pump). Cytochromes carry electrons in the electron transport

chain in mitochondria.

Receptors: for hormones (e.g. insulin and glucagon) and

neurotransmitters (e.g. acetylcholine). Hormones: e.g. insulin is a protein.

Defence: antibodies bind to specific antigens on pathogens. Mass

transport: haemoglobin carries oxygen in red blood cells.

Gene expression: RNA polymerase, histones and repressors. Plasma

albumins maintain the water potential of the blood.

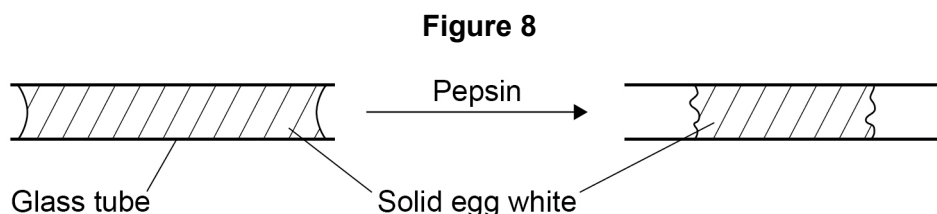


0 6 . 2

Pepsin is a protease enzyme produced by the human stomach.

Egg white contains the protein albumen.

Figure 8 shows the effect of pepsin on solid egg white.



Plan an experiment to find the optimum pH for the action of pepsin on egg white. Use the equipment shown in **Figure 8**.

[6 marks]

Fill identical glass tubes with solid egg white and cut them to the same length, e.g. 2 cm. Put each tube in the same volume of buffer solution at a different pH, using a range of at least 5 pH values, e.g. pH 1, 2, 3, 4, 5, 6 and 7.

Put a set volume and concentration of pepsin solution, e.g. 5 cm³ of 1%, in the same buffer in a separate tube at each pH value.

Keep all tubes at the same constant temperature, e.g. 37 °C, in a water bath and leave them to equilibrate for 5 minutes, then add the pepsin solution to each egg white tube.

Measure the length of egg white digested (cleared) with a ruler after a set time, e.g. 24 hours, and calculate the rate.

Repeat at least twice more at each pH and calculate a mean.

Plot a line graph of mean rate against pH; the optimum pH gives the maximum rate. Then repeat with intermediate pH values around the peak.

Turn over ►



0 6 . 3

Describe how proteins are coded for and synthesised in **prokaryotic** cells.**[6 marks]**

A gene is a sequence of DNA bases that determines the amino acid sequence (primary structure) of a polypeptide. A triplet of 3 bases codes for one amino acid.

Transcription: in the cytoplasm, the DNA unwinds and RNA polymerase joins free RNA nucleotides that pair by complementary base pairing with the template strand, forming mRNA.

Translation: the mRNA binds to a ribosome (70S). Translation begins at the start codon (AUG). Each tRNA carries a specific amino acid; its anticodon binds to the complementary codon on mRNA by hydrogen bonds.

Peptide bonds form between adjacent amino acids by condensation (using ATP), and the ribosome moves along the mRNA until a stop codon, e.g. UAA, is reached and the polypeptide is released.

The polypeptide chain folds into its specific 3-D shape, held by hydrogen bonds, ionic bonds, hydrophobic interactions and disulfide bonds.

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

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