Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

A-level BIOLOGY

Paper 3

Wednesday 21 June 2023 Morning Time allowed: 2 hours

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 in **Section A**.
- Answer **one** question from **Section B**.
- 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 78.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
TOTAL	

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Section A

Answer **all** questions in this section.

You are advised to spend no more than 1 hour and 15 minutes on this section.

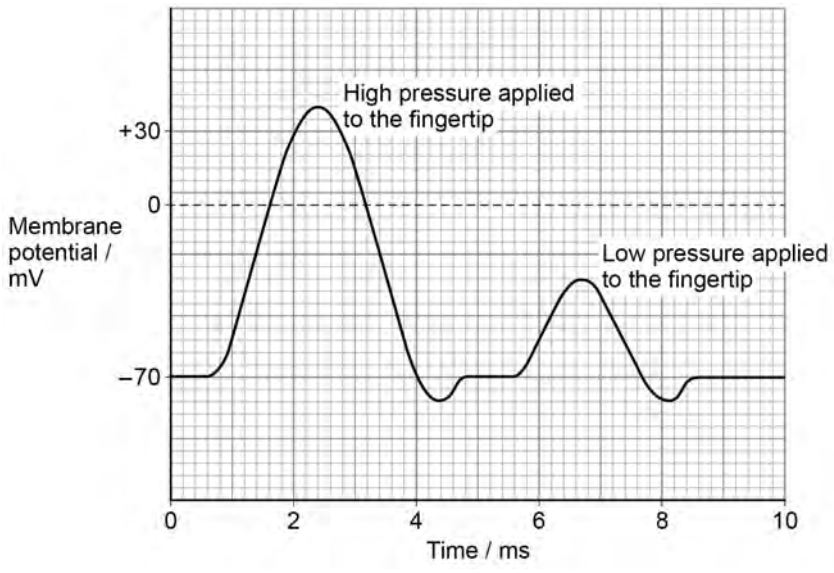
0 1 . 1 Describe how stimulation of a Pacinian corpuscle produces a generator potential.

[3 marks]

Scientists investigated the stimulation of a Pacinian corpuscle in the skin of a fingertip. The scientists applied two different pressures to the fingertip and recorded the changes in membrane potential of the Pacinian corpuscle's sensory neurone.

Figure 1 shows the scientists' results.

Figure 1



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0 1 . 2 Use **Figure 1** to describe what is meant by the all-or-nothing principle.

[2 marks]

0 1 . 3 On **Figure 1**, from 0.6 ms to 4.0 ms, no new generator potential could be produced. What is this time period called?

[1 mark]

6

Turn over for the next question

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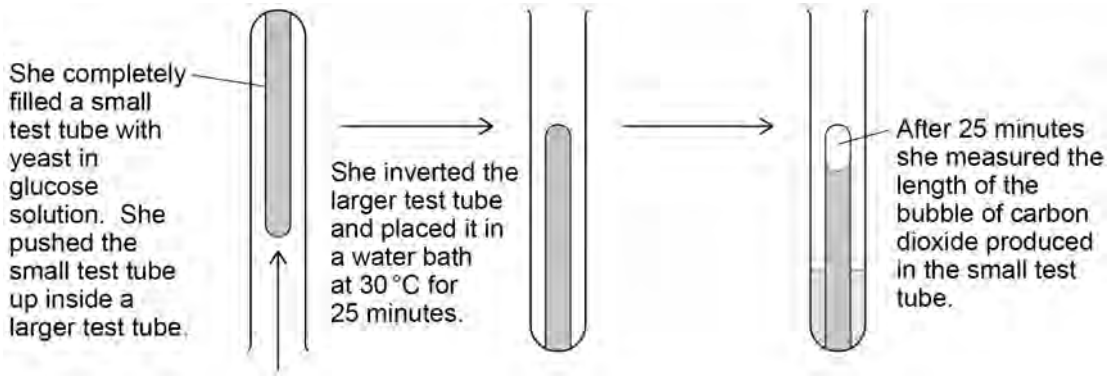
0 2 A student investigated the effect of different sugars on the rate of respiration in yeast. Yeast normally respires glucose.

Figure 2 shows the method she used for her first experiment.

Figure 2



0 2 . 1 Other than those stated, suggest **two** variables the student needed to keep constant in her investigation.

[1 mark]

1 _____

2 _____

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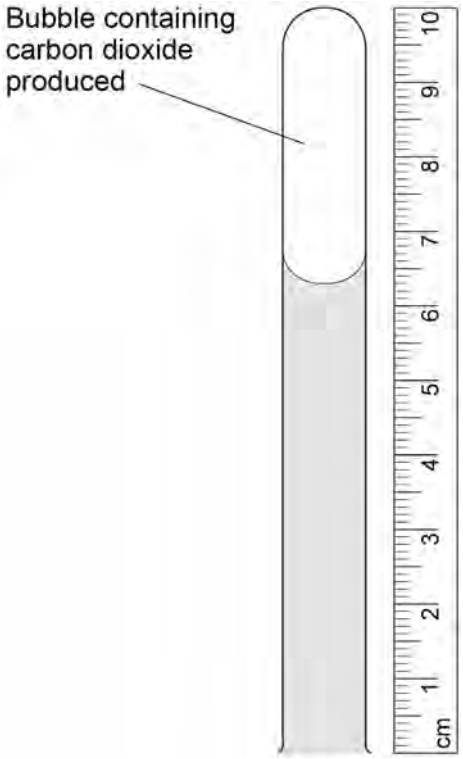
Figure 3 shows the result she obtained for yeast in glucose solution.

Figure 3



0 2 . 2 Use **Figure 2** and **Figure 3** to calculate the rate of carbon dioxide production in mm s^{-1} for yeast in glucose solution.

Give your answer in standard form **and** to **2** significant figures.

Show your working.

[2 marks]

Answer _____ mm s^{-1}

Turn over ►

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0 2 . 3 The student repeated the experiment using yeast in maltose solution. She found the rate of carbon dioxide production was slower than with yeast in glucose solution. Suggest why.

[2 marks]

0 2 . 4 A second student used a different method to investigate the effect of different sugars on the rate of respiration in yeast.

He set up a tube with yeast in glucose solution and added bromothymol blue. Bromothymol blue changes from blue to yellow when carbon dioxide is produced.

To determine the rate of respiration, he timed how long it took for the solution to change from blue to yellow.

Suggest:

- why the method the second student used would be less accurate than the method the first student used
- how the accuracy of the method the second student used could be improved.

[2 marks]

This method would be less accurate because

The accuracy of this method could be improved by

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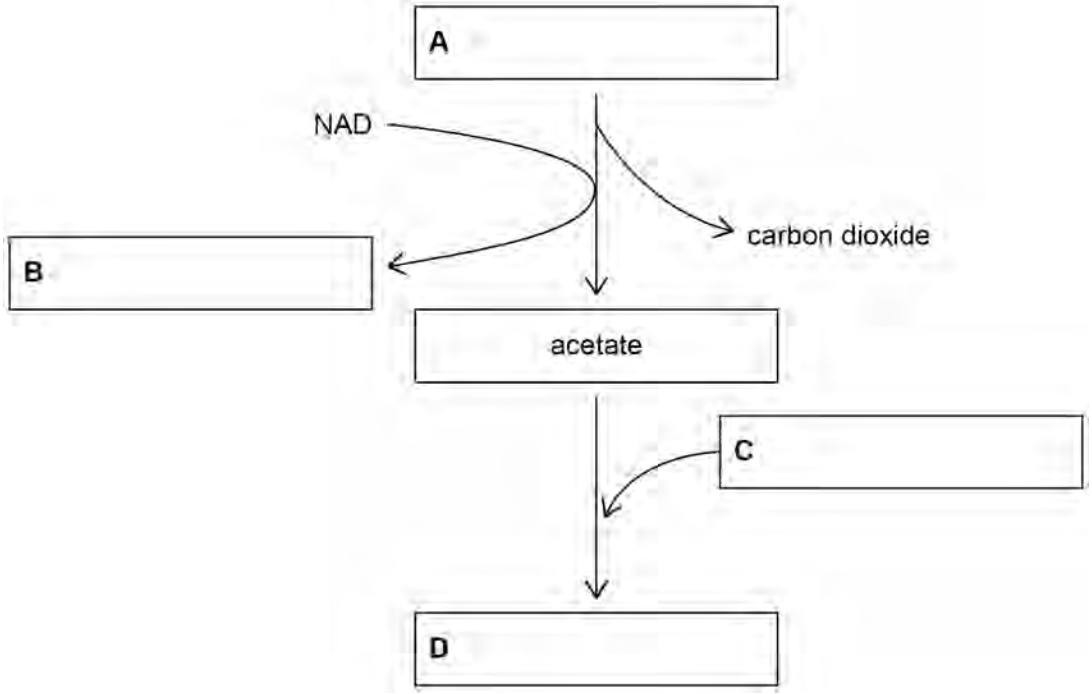
0 2 . 5 Complete the boxes **A** to **D** in **Figure 4** to show the link reaction.

Figure 4



[2 marks]

9

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0 3 . 1 Below are **four** statements about the structure of prokaryotic cells.

1. No prokaryotic cell has DNA that is associated with proteins.
2. No prokaryotic cell has membrane-bound organelles.
3. All prokaryotic cells have one or more flagella.
4. All prokaryotic cells have smaller ribosomes than eukaryotic cells.

Which statements about the structure of prokaryotic cells are correct?

Tick (✓) **one** box.

[1 mark]

A statements **1**, **2** and **3** ☐

B statements **1**, **2** and **4** ☐

C statements **2**, **3** and **4** ☐

D statements **1**, **2**, **3** and **4** ☐

A student investigated the effect of **two** antibiotics on the growth of the bacterium *Micrococcus luteus*.

During the investigation, the student:

- transferred 9 cm^3 of a liquid culture of *M. luteus* into each of **three** bottles
- added the antibiotic chloramphenicol to the first bottle
- added the antibiotic novobiocin to the second bottle
- added no antibiotic to the third bottle.

After 24 hours, he diluted the contents of each bottle by 1 in 100 000 (10^{-5}). He then transferred 0.25 cm^3 samples from the first bottle onto each of 3 separate agar plates. He repeated this with 0.25 cm^3 samples from the second bottle and the third bottle, resulting in 9 agar plates in total.

He incubated the plates for 48 hours.

Table 1 shows the number of colonies of bacteria he counted on each plate after 48 hours' incubation.

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Table 1

Plate	Number of colonies of bacteria		
	with chloramphenicol	with novobiocin	with no antibiotic
1	2	238	276
2	4	263	258
3	6	261	324

0 3 . 2 Calculate the mean number of bacteria in the **undiluted** bottle of liquid culture containing novobiocin.

Give your answer in standard form. Show your working.

[2 marks]

Answer _____ bacteria

0 3 . 3 Starting with a single bacterium, calculate how many generations it would take to produce at least the number of bacteria you have calculated for your answer in Question **03.2**

You can assume no bacteria die.

You could use the ln or log button on your calculator to calculate your answer.

[1 mark]

Answer _____ generations

Question 3 continues on the next page

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0 3 . 4 *M. luteus* is **not** resistant to chloramphenicol.

Suggest **two** reasons why the bacteria were able to grow in the culture containing chloramphenicol.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

6

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Turn over for the next question

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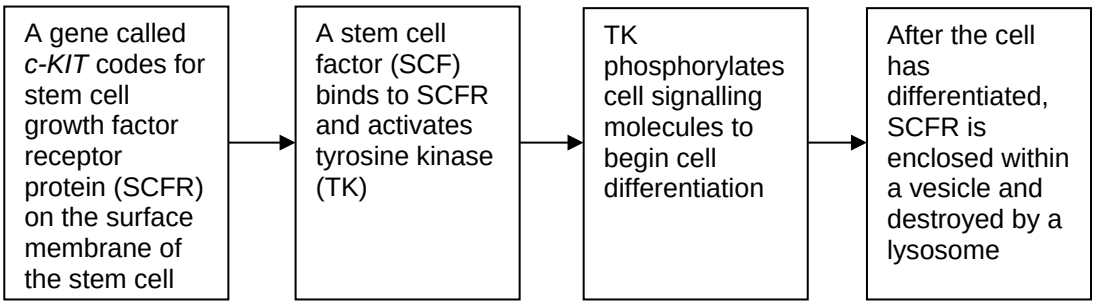
0 4 Following a body injury, bone marrow stem cells move to the site of damage and undergo cell differentiation.

Figure 5 shows how this differentiation occurs.

Figure 5



0 4 . 1 Suggest how SCFR is destroyed by a lysosome.

[2 marks]

After a heart attack, cardiomyocytes (cardiac muscle cells) die, and become infarcted tissue. Infarcted tissue cannot contract.

Stem cells in bone marrow **cannot** move to the infarcted tissue and differentiate into cardiomyocytes.
Scientists used laboratory rats to investigate if bone marrow stem cell transplants could be used to repair infarcted tissue resulting from a heart attack.

They split the rats into three groups.

- **Control** group did not get a transplant of bone marrow stem cells.
- **c-KIT+** group got a transplant of bone marrow stem cells with a functioning *c-KIT* gene.
- **c-KIT–** group got a transplant of bone marrow stem cells with **no** functioning *c-KIT* gene.

After 9 days, the scientists measured the mean ventricular blood pressure of each of the three groups.

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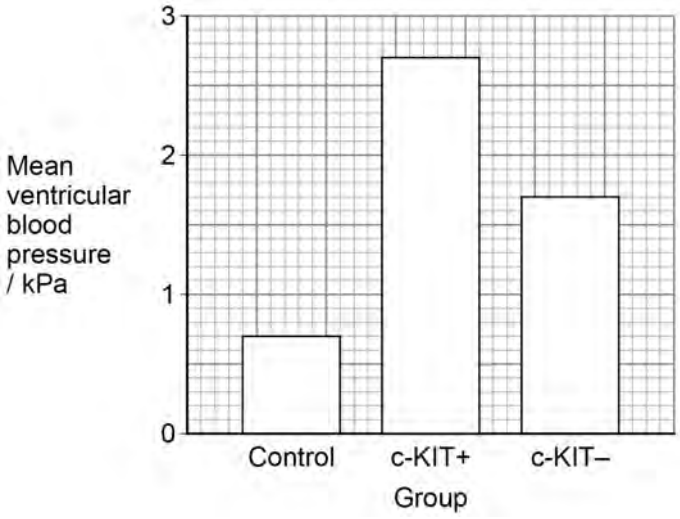
Figure 6 shows their results.

The differences between the groups were all statistically significant.

Figure 6



0 4 . 2 Using all of the information, suggest explanations for the results for the **Control** group and the **c-KIT–** group shown in **Figure 6**.

[4 marks]

Control

c-KIT–

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0 4 . 3 Nine days after transplantation, the **c-KIT+** group showed that 68% of infarcted tissue was made up of new cardiomyocytes. The control group had **no** new cardiomyocytes.

Assuming that mean ventricular blood pressure is directly proportional to the number of cardiomyocytes, calculate the percentage of infarcted tissue that was made up of new cardiomyocytes in the **c-KIT–** group.

[2 marks]

Answer _____ %

All new cardiomyocytes produced:

- Connexin-43, a channel protein that allows electrical impulses to pass between cardiomyocytes
- GATA-4, a transcriptional factor that stimulates the expression of genes for actin and myosin.

0 4 . 4 Suggest how production of Connexin-43 and GATA-4 could give the result seen in the **c-KIT+** group in **Figure 6** (on page 13).

Do **not** include details of transcription or translation in your answer.

[2 marks]

Connexin-43 _____

GATA-4 _____

10

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Turn over for the next question

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0 5 Scientists investigated the effect that the release of heated water into a river from a power station had on the biodiversity of a local fish community over 29 years.

They measured the species richness and the number of fish of each species at the same site in October every year. The scientists used this information to calculate an index of diversity (*d*) of fish for each year.

Figure 7 and **Figure 8** show their results.

Figure 7

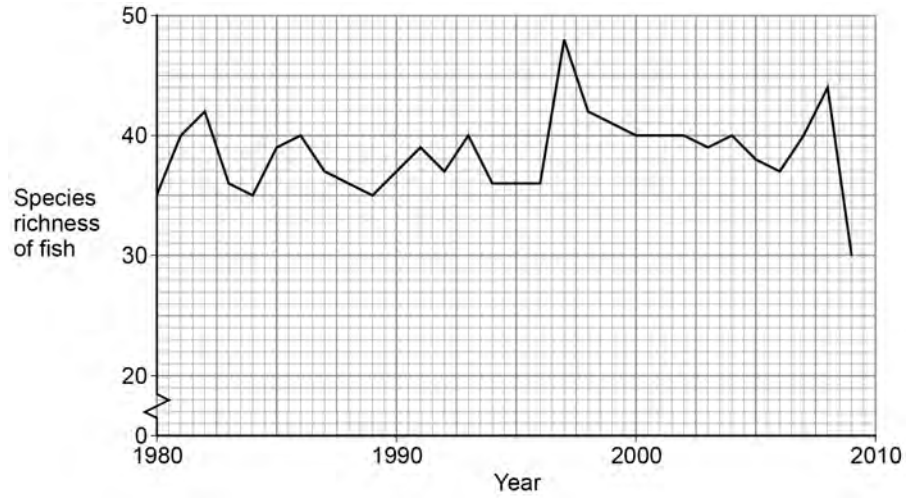
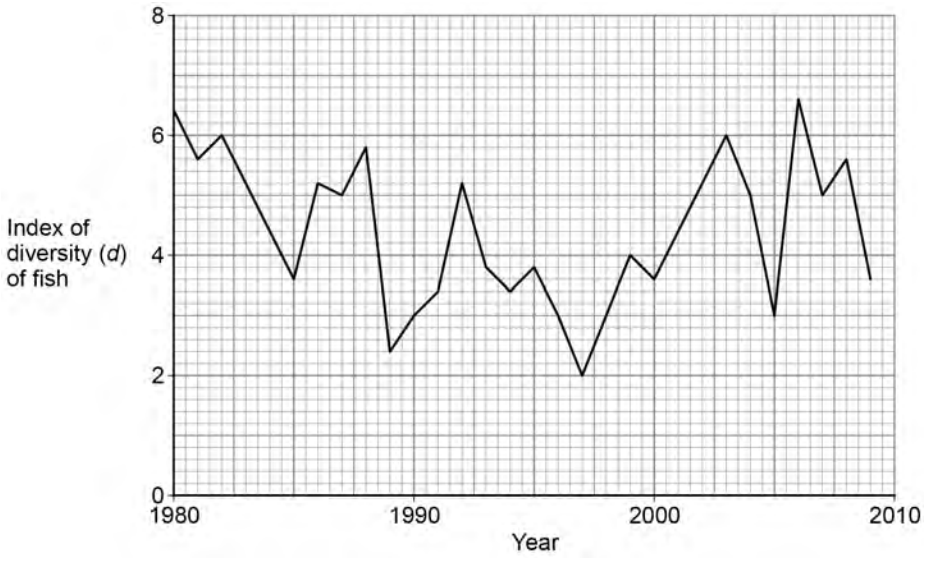


Figure 8



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0 5 . 1 The scientists used the following formula to calculate the index of diversity (d) of fish.

$$d = \frac{N\,(N-1)}{\Sigma n\,(n-1)}$$

where N = total number of fish of all species
and n = total number of fish of each species

In some years, the values were $N = 624$ and $\Sigma n\,(n-1) = 64\,792$

Which years had these values?

Use **Figure 8** and the formula above to work out your answer.

[1 mark]

Answer _____

0 5 . 2 In 1997, the scientists recorded the highest species richness, but the lowest value of d over the 29 years.

Describe **and** explain how these results for 1997 were possible.

[2 marks]

_____

_____

_____

_____

_____

_____

Question 5 continues on the next page

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0 5 . 3 A journalist studied **Figure 7** and **Figure 8** (on page 16) and concluded that releasing heated water from a power station has no effect on local fish communities.

Use all the information to suggest reasons why the journalist's conclusion might **not** be valid.

[4 marks]

7

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0 6 . 1 Give **two** types of cell that can stimulate an immune response.

[2 marks]

1 _____

2 _____

An autoimmune disease causes the immune system to attack healthy body tissues. Scientists investigated the immune responses of healthy mice and mice with autoimmune disease.

The chemical OXA causes an immune response in mice and can make their skin swell. Mice had olive oil applied to their left ear and OXA in olive oil applied to their right ear.

The immune response was recorded in two ways:

- the cellular response by measuring the mean increase in ear thickness 24 hours after exposure to OXA
- the humoral response by measuring the mean concentration of anti-OXA antibody in blood 14 days after exposure to OXA.

Table 2 shows the results of this investigation. The values in the brackets show ± 2 standard deviations. A value of ± 2 standard deviations from the mean includes over 95% of the data.

Table 2

Type of mice	Sex of mice	Mean increase in ear thickness / cm × 10^{-3}	Mean concentration of anti-OXA antibody / arbitrary units
Healthy	Male	17.9 (±4.1)	16 (±3)
	Female	18.5 (±2.9)	14 (±4)
Autoimmune disease	Male	25.9 (±4.5)	14 (±2)
	Female	16.7 (±3.0)	26 (±7)

0 6 . 2 Suggest and explain **one** reason why olive oil was applied to the left ear of the mice.

[1 mark]

_____

_____

_____

_____

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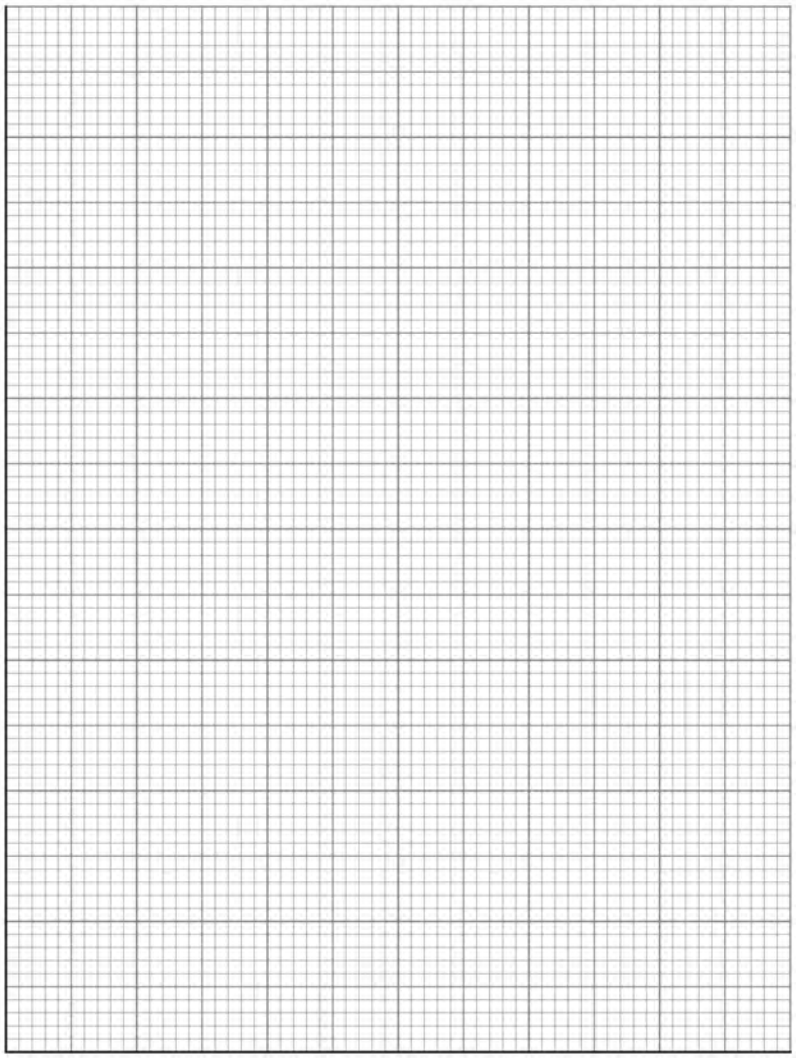
0 6 . 3 Plot a suitable graph for mean increase in ear thickness for each group of mice in **Table 2**.

Include the data for ± 2 standard deviations on your graph.

[3 marks]



Question 6 continues on the next page

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0 6 . 4 What can you conclude about the effects of autoimmune disease on the cellular response and the humoral response in male and female mice?

Use the data to justify your conclusions.

[3 marks]

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0 6 . 5 Some studies have shown that **in humans**, oestrogen has the opposite effect on two different autoimmune diseases. Oestrogen:

- accelerates the progression of systemic lupus erythematosus (SLE)
- prevents the progression of rheumatoid arthritis (RA).

The scientists investigated the effect of oestrogen on the immune response in healthy mice and mice with autoimmune disease.

Table 3 shows the scientists' results.

Table 3

Type of mice	Effect of oestrogen on humoral response	Effect of oestrogen on cellular response
Healthy	No effect	No effect
Autoimmune disease	Increase in response	Decrease in response

A student studying these data made the following conclusions.

1. In humans, SLE is caused by an overproduction of antibodies.
2. In humans, RA is caused by an overproduction of cytotoxic T cells (T_C cells).

Evaluate the student's conclusions.

[4 marks]

Question 6 continues on the next page

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0 6 . 6 In mice, one type of autoimmune disease is inherited as a dominant allele. Would the Hardy–Weinberg principle hold true for a population of mice, some of which had this autoimmune disease?

Explain your answer.

[2 marks]

15

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Section B

Answer **one** question.

You are advised to spend no more than 45 minutes on this section.

0 7 Write an essay on **one** of the topics below.

Either

0 7 . 1 The importance of interactions between organisms and their environment.

[25 marks]

Or

0 7 . 2 The importance of membranes in the functioning of cells.

[25 marks]

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END OF QUESTIONS

25

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