

A



Surname \_\_\_\_\_

Forename(s) \_\_\_\_\_

Centre Number \_\_\_\_\_

Candidate Number \_\_\_\_\_

Candidate Signature \_\_\_\_\_

I declare this is my own work.

**A-level**

**BIOLOGY**

**Paper 3**

**7402/3**

**Wednesday 21 June 2023**

**Morning**

**Time allowed: 2 hours**

**At the top of the page, write your surname and forename(s), your centre number, your candidate number and add your signature.**

**[Turn over]**



J U N 2 3 7 4 0 2 3 0 1

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**MATERIALS**

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator.

**INSTRUCTIONS**

- Use black ink or black ball-point pen.
- Answer ALL questions in SECTION A.
- Answer ONE question from SECTION B.
- You must answer the questions in the spaces provided. Do not write 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.

**DO NOT TURN OVER UNTIL TOLD TO DO SO**



**SECTION A**

**Answer ALL questions in this section.**

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

**01.1**

**Describe how stimulation of a Pacinian corpuscle produces a generator potential. [3 marks]**

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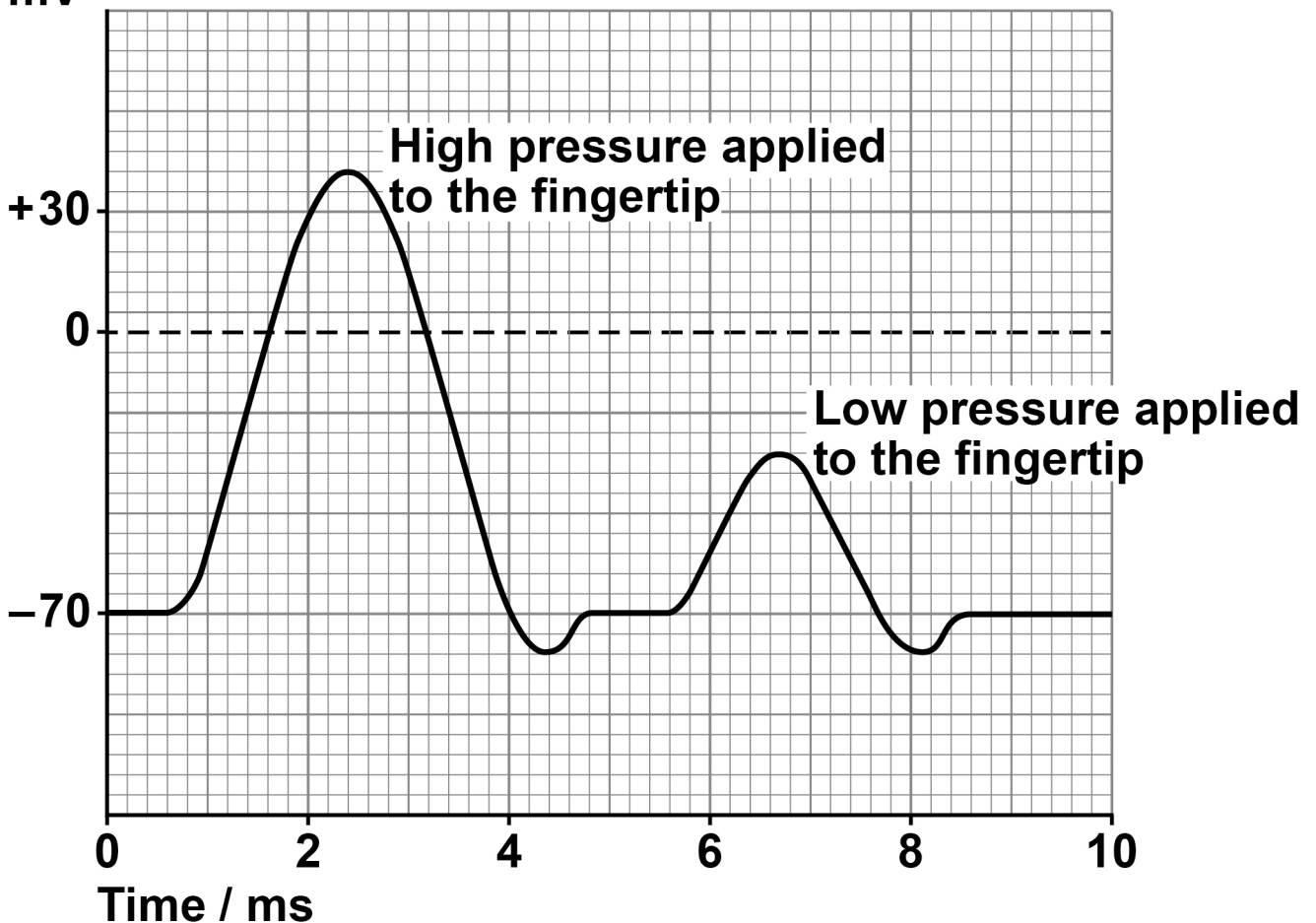


Scientists investigated the stimulation of a Pacinian corpuscle in the skin of a fingertip. The scientists applied two different pressures to the fingertip and recorded the changes in membrane potential of the Pacinian corpuscle's sensory neurone.

FIGURE 1 shows the scientists' results.

FIGURE 1

Membrane potential / mV



**01.2**

Use FIGURE 1 to describe what is meant by the all-or-nothing principle. [2 marks]

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**01.3**

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]

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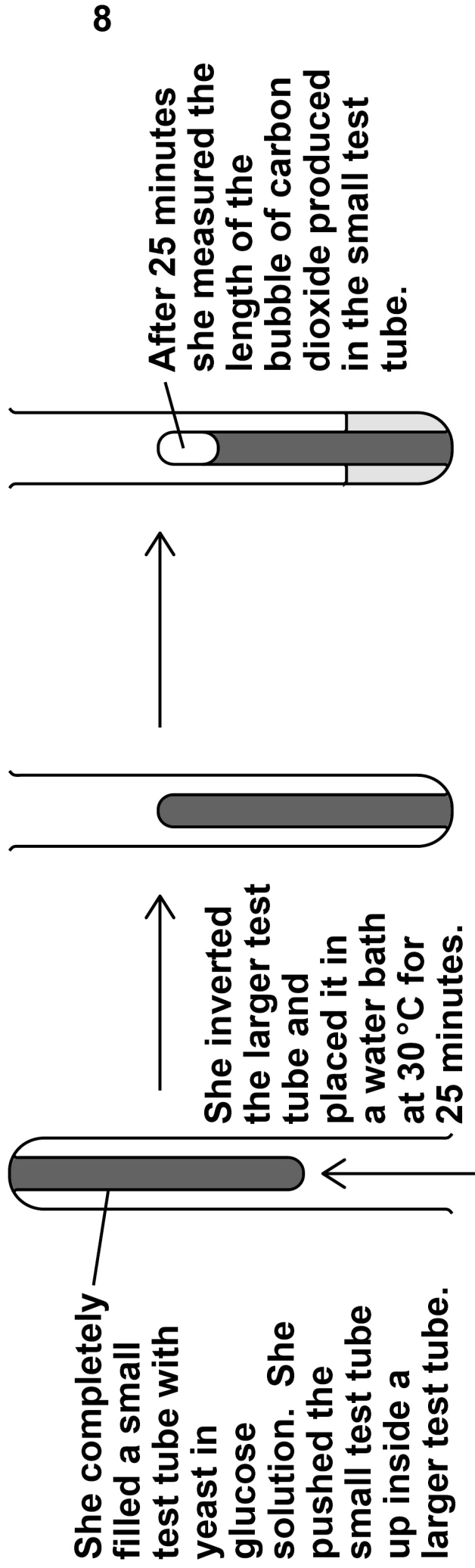


02

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

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

FIGURE 2







02.1

Other than those stated, suggest TWO variables the student needed to keep constant in her investigation. [1 mark]

1 \_\_\_\_\_

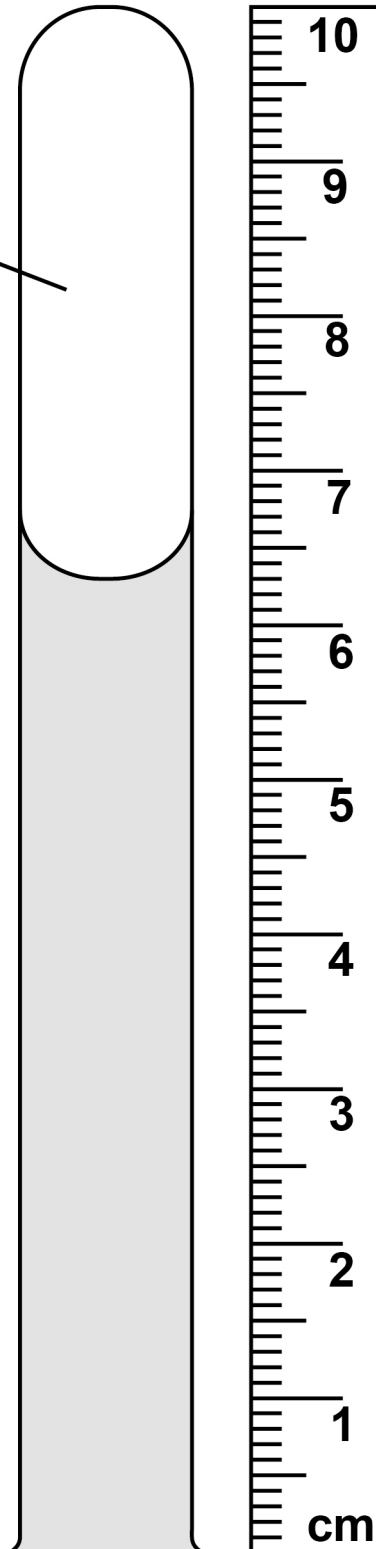
2 \_\_\_\_\_

[Turn over]

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

**FIGURE 3**

**Bubble containing  
carbon dioxide  
produced**



**0 2 . 2**

Use FIGURE 2, on page 8, and FIGURE 3 to calculate the rate of carbon dioxide production in  $\text{mm s}^{-1}$  for yeast in glucose solution.

Give your answer in standard form AND to 2 significant figures.

Show your working. [2 marks]

Answer \_\_\_\_\_  $\text{mm s}^{-1}$

[Turn over]



**02.3**

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]

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**02.4**

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**

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**The accuracy of this method could be improved by**

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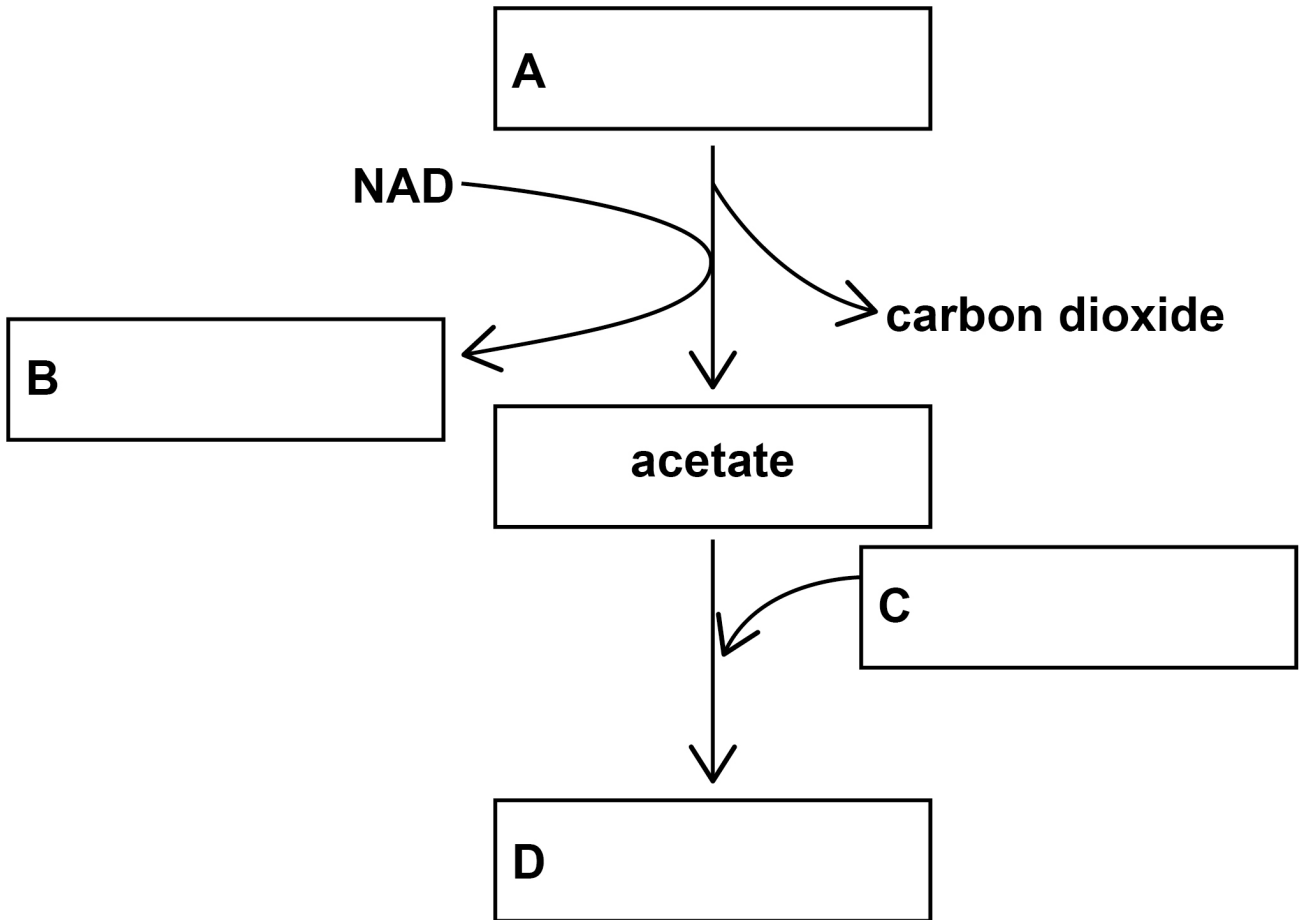
**[Turn over]**



02.5

Complete the boxes A to D in FIGURE 4 to show the link reaction. [2 marks]

FIGURE 4



9



**03.1**

**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**

**[Turn over]**



**A student investigated the effect of TWO antibiotics on the growth of the bacterium ‘Micrococcus luteus’.**

**During the investigation, the student:**

- **transferred 9 cm<sup>3</sup> 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<sup>3</sup> samples from the first bottle onto each of 3 separate agar plates. He repeated this with 0.25 cm<sup>3</sup> 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, on the opposite page, shows the number of colonies of bacteria he counted on each plate after 48 hours’ incubation.**





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

03.2

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

[Turn over]



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**03.3**

**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, on page 17.**

**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**

**[Turn over]**



**03.4**

**'M. luteus' is NOT resistant to chloramphenicol.**

**Suggest TWO reasons why the bacteria were able to grow in the culture containing chloramphenicol.  
[2 marks]**

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**2**

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6



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**[Turn over]**



**04**

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

A gene called *c-KIT* codes for stem cell growth factor receptor protein (SCFR) on the surface membrane of the stem cell



A stem cell factor (SCF) binds to SCFR and activates tyrosine kinase (TK)



TK phosphorylates cell signalling molecules to begin cell differentiation



After the cell has differentiated, SCFR is enclosed within a vesicle and destroyed by a lysosome



04.1

**Suggest how SCFR is destroyed by a lysosome.  
[2 marks]**

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**[Turn over]**



**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.**

**FIGURE 6, on page 26, shows their results.**

**The differences between the groups were all statistically significant.**





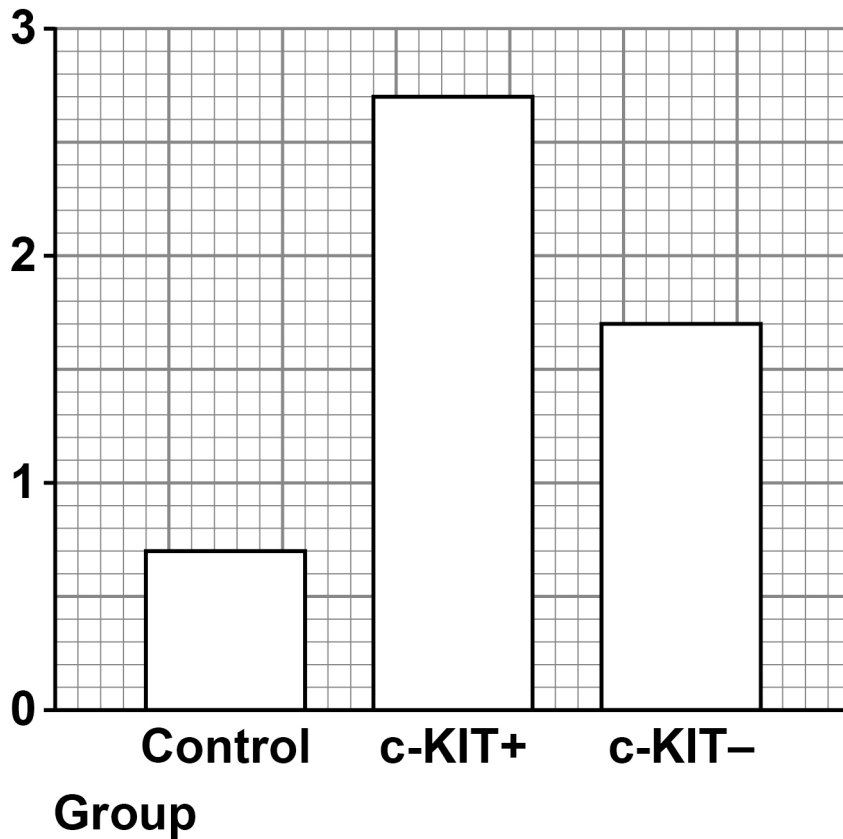
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**[Turn over]**



FIGURE 6

Mean  
ventricular  
blood  
pressure  
/ kPa



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 \_\_\_\_\_

\_\_\_\_\_



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**c-KIT-** \_\_\_\_\_

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**[Turn over]**



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**04.3**

**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]**

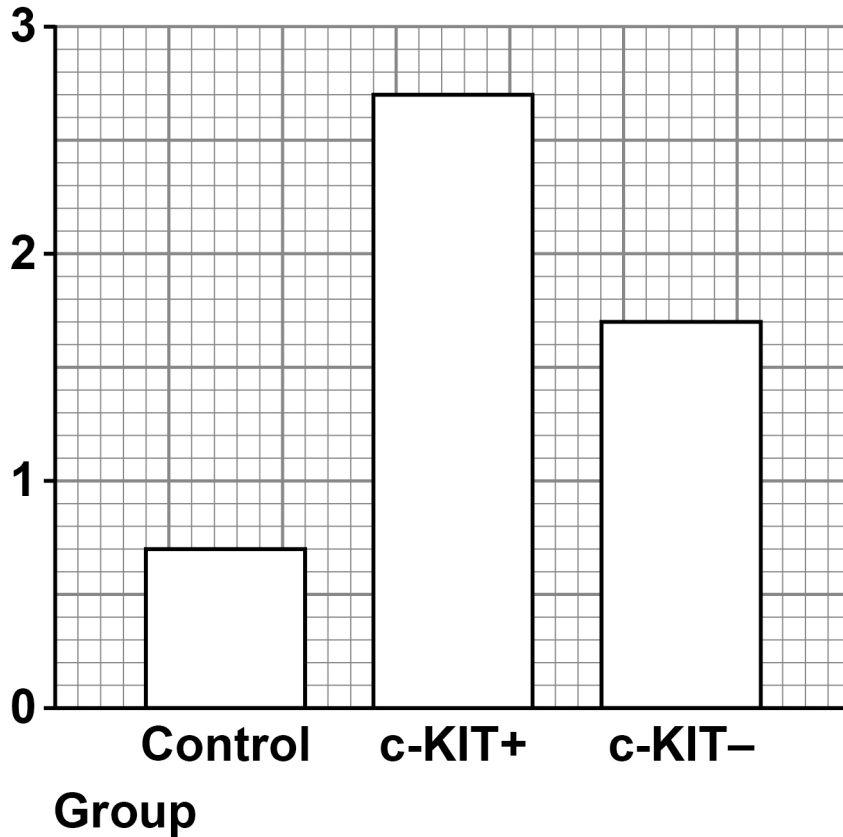
**Answer \_\_\_\_\_ %**

**[Turn over]**



**REPEAT OF FIGURE 6**

**Mean  
ventricular  
blood  
pressure  
/ kPa**



**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.



04.4

**Suggest how production of Connexin-43 and GATA-4 could give the result seen in the c-KIT+ group in FIGURE 6.**

**Do NOT include details of transcription or translation in your answer. [2 marks]**

**Connexin-43** \_\_\_\_\_

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**GATA-4** \_\_\_\_\_

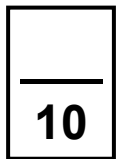
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**[Turn over]**



**05**

**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, on page 33, and FIGURE 8, on page 34, show their results.**

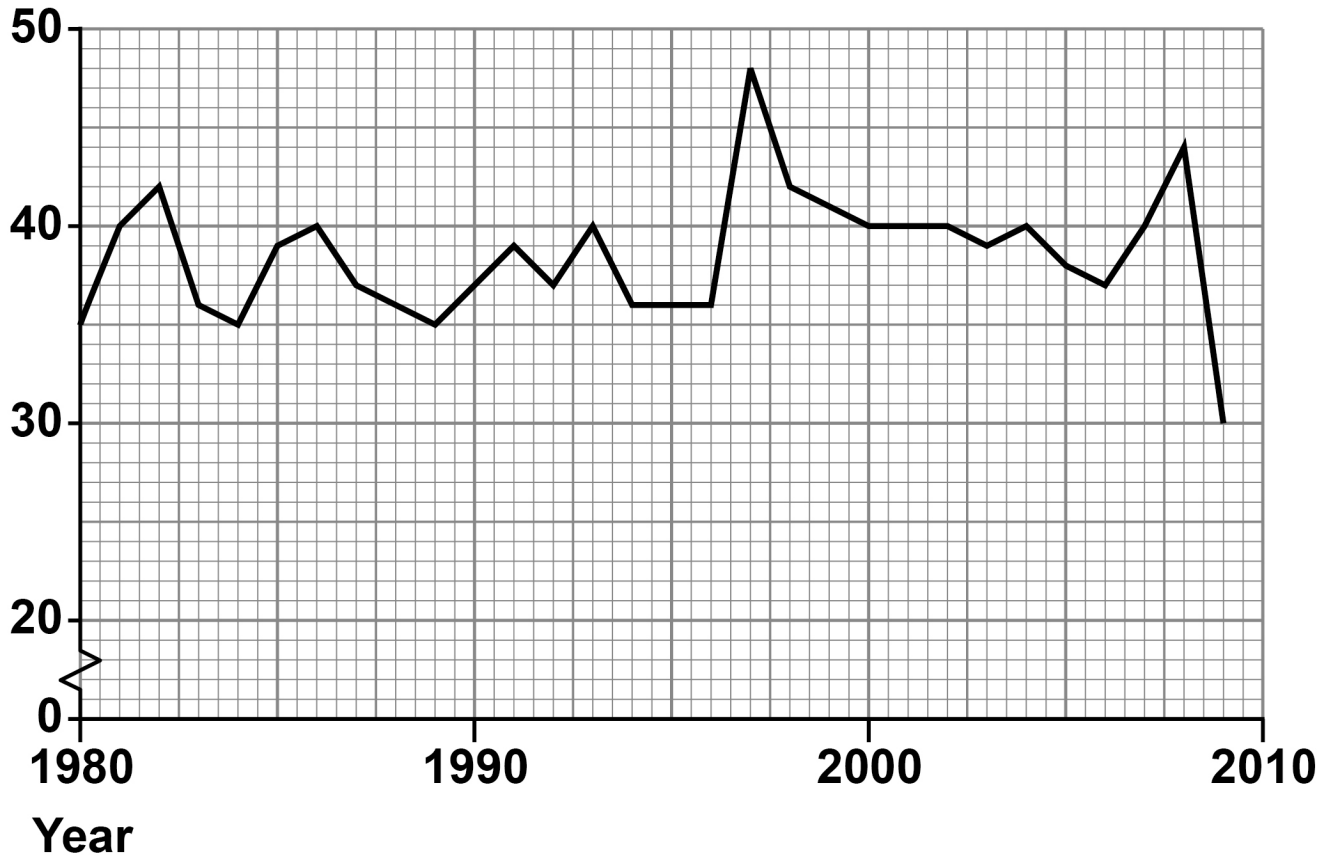
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FIGURE 7

Species  
richness  
of fish

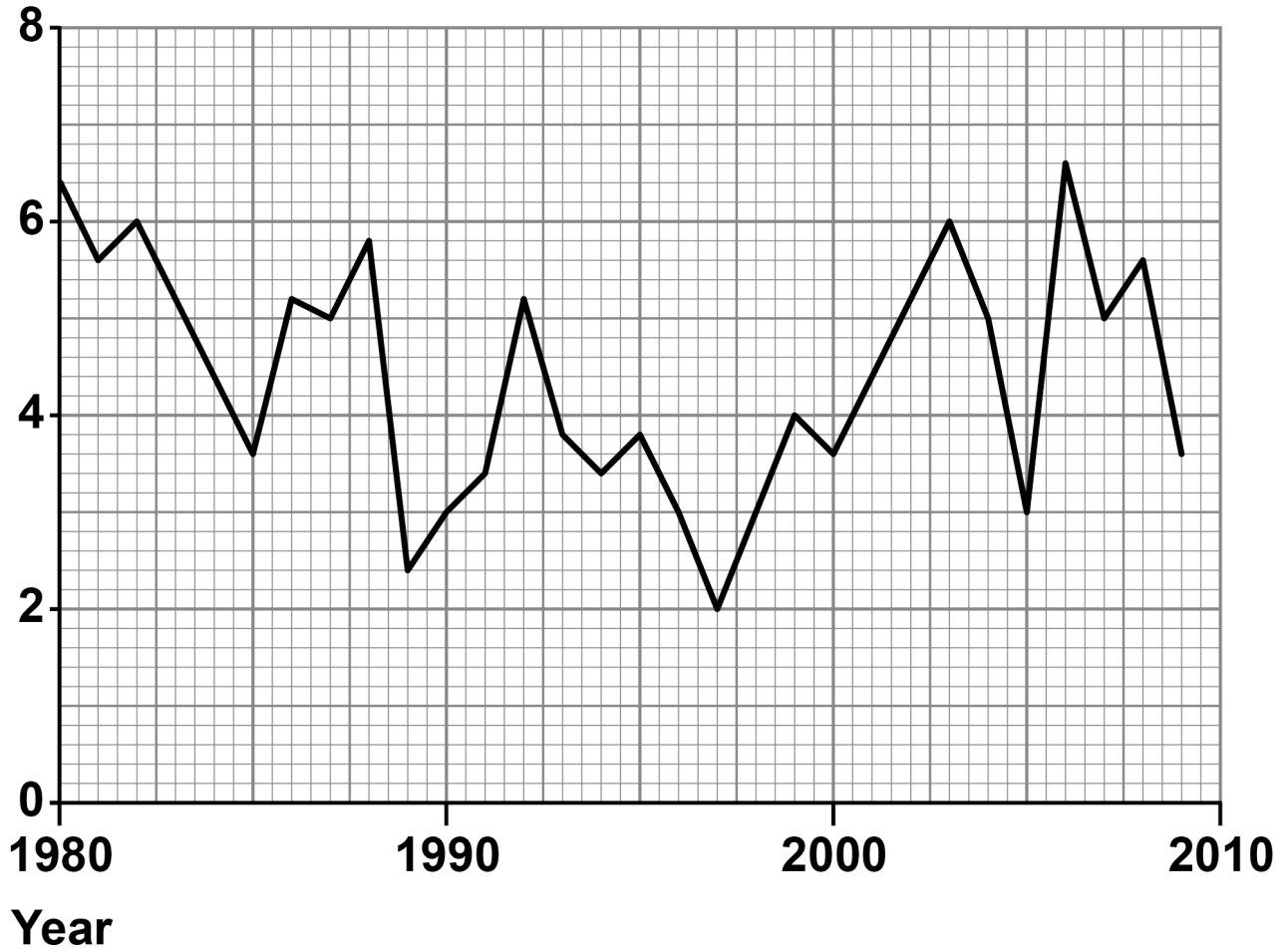


[Turn over]



FIGURE 8

Index of  
diversity ( $d$ )  
of fish



**05.1**

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

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

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  
 $\sum n(n-1) = 64\,792$

Which years had these values?

Use FIGURE 8 and the formula above to work out your answer. [1 mark]

Answer \_\_\_\_\_

[Turn over]



05.2

**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]**

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**05.3**

**A journalist studied FIGURE 7 and FIGURE 8 (on pages 33 and 34) 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]**

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**06.1**

**Give TWO types of cell that can stimulate an immune response. [2 marks]**

**1**

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**2**

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**[Turn over]**



**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, on the opposite page, shows the results of this investigation. The values in the brackets show  $\pm 2$  standard deviations. A value of  $\pm 2$  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 $\times 10^{-3}$	Mean concentration of anti-OXA antibody / arbitrary units
Healthy	Male	17.9 ( $\pm 4.1$ )	16 ( $\pm 3$ )
	Female	18.5 ( $\pm 2.9$ )	14 ( $\pm 4$ )
Autoimmune disease	Male	25.9 ( $\pm 4.5$ )	14 ( $\pm 2$ )
	Female	16.7 ( $\pm 3.0$ )	26 ( $\pm 7$ )

06.2

Suggest and explain ONE reason why olive oil was applied to the left ear of the mice. [1 mark]

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## REPEAT OF TABLE 2

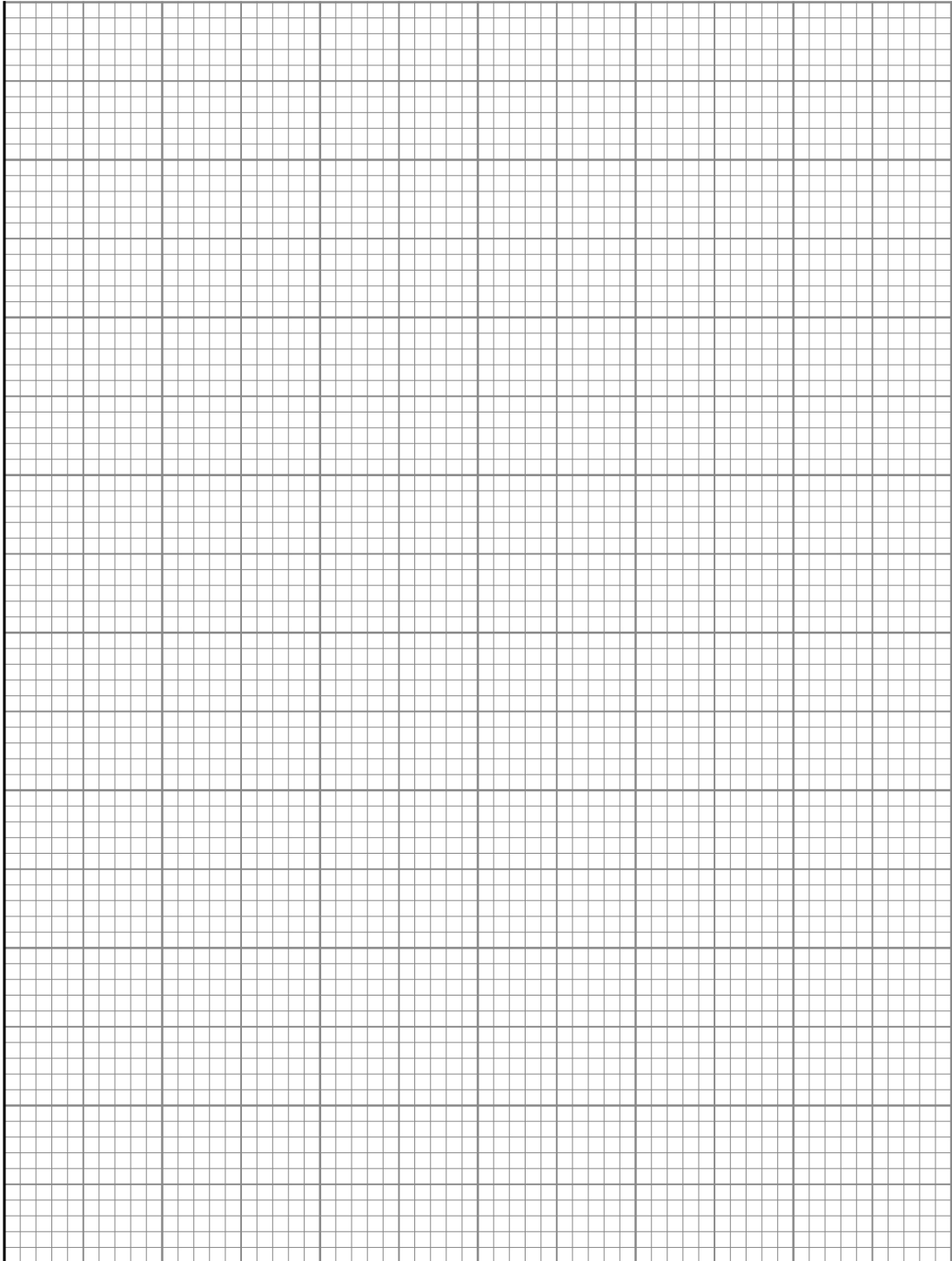
Type of mice	Sex of mice	Mean increase in ear thickness / cm $\times 10^{-3}$	Mean concentration of anti-OXA antibody / arbitrary units
Healthy	Male	17.9 ( $\pm 4.1$ )	16 ( $\pm 3$ )
	Female	18.5 ( $\pm 2.9$ )	14 ( $\pm 4$ )
Autoimmune disease	Male	25.9 ( $\pm 4.5$ )	14 ( $\pm 2$ )
	Female	16.7 ( $\pm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

06.3

On the opposite page, plot a suitable graph for mean increase in ear thickness for each group of mice in TABLE 2.

Include the data for  $\pm 2$  standard deviations on your graph. [3 marks]





**[Turn over]**



06.4

**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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06.5

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.





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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]

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**SECTION B**

**Answer ONE question.**

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

**07**

**Write an essay on ONE of the topics below.**

**EITHER**

**07.1**

**The importance of interactions between organisms and their environment. [25 marks]**

**OR**

**07.2**

**The importance of membranes in the functioning of cells. [25 marks]**

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**END OF QUESTIONS**

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**Additional page, if required.**

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For Examiner's Use	
Question	Mark
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<b>TOTAL</b>	

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