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

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	
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 Amino acids are used to make proteins. **Table 1** shows the R groups of six different amino acids.

Table 1

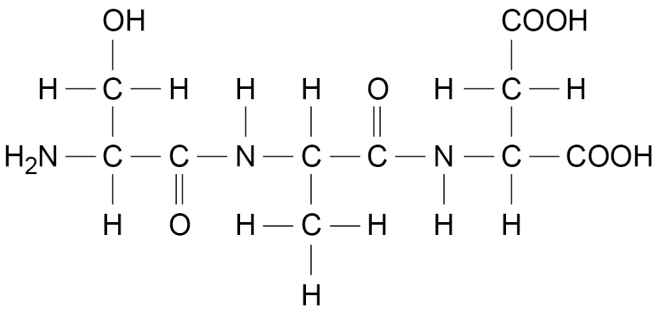
Amino acid	R group
Alanine	CH_3
Asparagine	CH_2CONH_2
Aspartic acid	CH_2COOH

Amino acid	R group
Glutamic acid	CH_2CH_2COOH
Glycine	H
Serine	CH_2OH

0 1 . 1 Use **Table 1** to identify the **three** different amino acids used to make the polypeptide shown in **Figure 1**.

[2 marks]

Figure 1



Left amino acid _____

Middle amino acid _____

Right amino acid _____

Question 1 continues on the next page

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0 1 . 2 **Table 2** shows three statements and names of four biological molecules.

Put a tick (✓) in each box where the statement is true for the biological molecule.

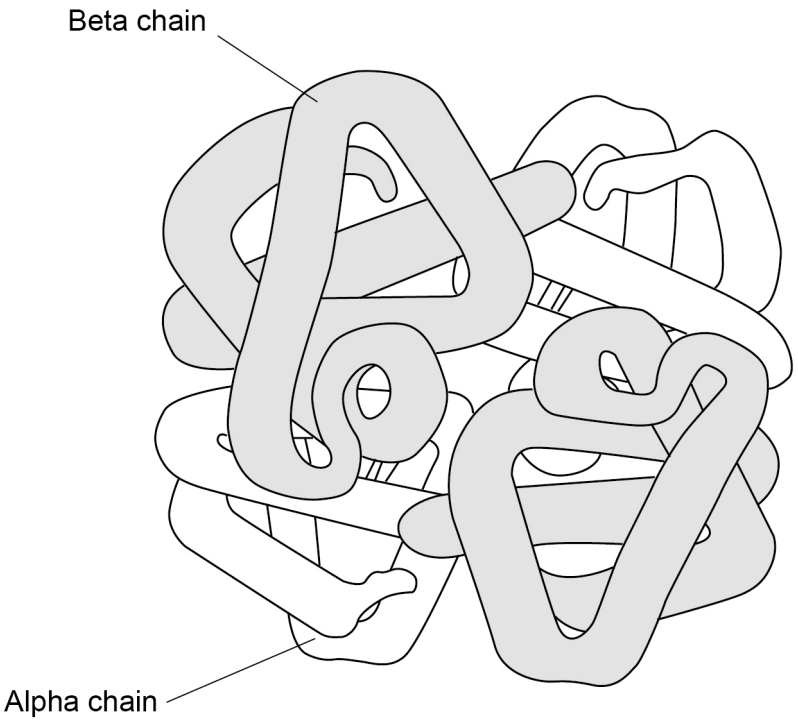
[3 marks]

Table 2

Statement	**DNA**	**ATP**	**Reverse transcriptase**	**Phospholipid**
Contains peptide bonds				
Is formed using a condensation reaction				
Is a polymer				

Figure 2 represents the structure of adult human haemoglobin.

Figure 2



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0 1 . 3 The number of amino acids in the beta chains in **Figure 2** is 3.546% greater than in the alpha chains. Each alpha chain contains 141 amino acids.

Calculate how many amino acids there are in total in the haemoglobin molecule shown in **Figure 2**. Give your answer to the nearest whole number.

[2 marks]

Answer _____ amino acids

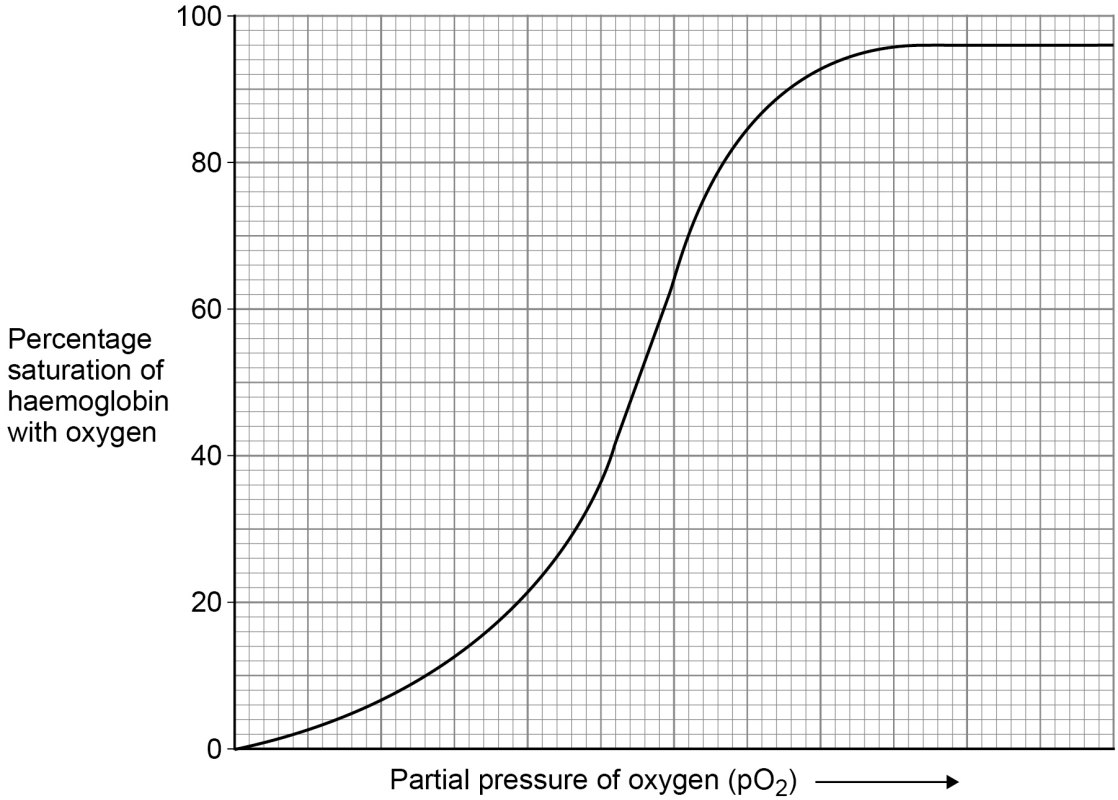
When a substance called BPG binds to haemoglobin, it reduces the affinity of haemoglobin for oxygen.

0 1 . 4 **Figure 3** shows an oxyhaemoglobin dissociation curve for haemoglobin in normal conditions.

Sketch a curve on **Figure 3** to show the oxyhaemoglobin dissociation curve for haemoglobin when BPG binds to it.

[1 mark]

Figure 3



Question 1 continues on the next page

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0 1 . 5 Suggest and explain when it would be an advantage to a human for BPG to bind to haemoglobin.

[2 marks]

10

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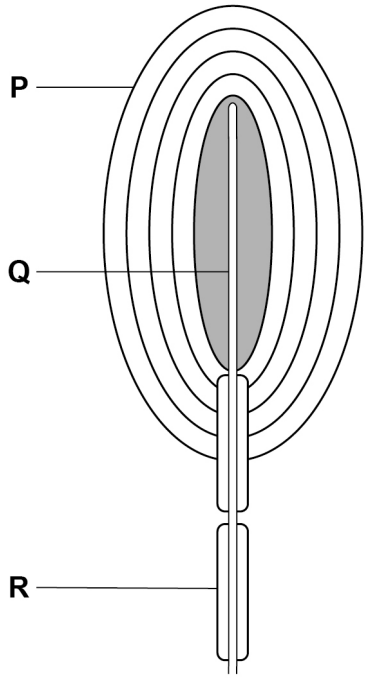
0 2 **Figure 4** shows a diagram of a Pacinian corpuscle.

Figure 4



0 2 . 1 Name the structures labelled **P**, **Q** and **R** shown in **Figure 4**.

[2 marks]

P _____

Q _____

R _____

Question 2 continues on the next page

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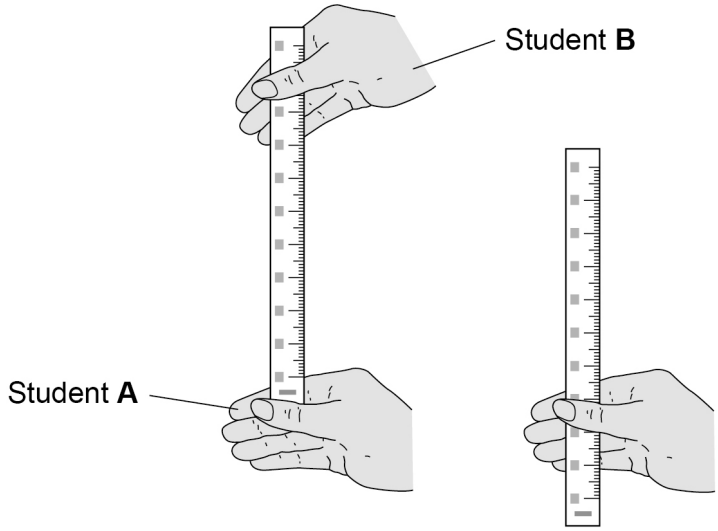
Two students (**A** and **B**) investigated reaction time in response to touch.

- Student **A** sat with her eyes shut and her forearm resting on a worktop so that her hand was over the edge.
- Student **B** held a ruler vertically between student **A**'s thumb and first finger, with the ruler at 0 mm lightly touching student **A**'s first finger.
- Student **B** released the ruler.
- As soon as student **A** felt the ruler fall, she closed her thumb and first finger to catch the ruler as shown in **Figure 5**.
- Student **B** measured the distance the ruler had fallen to the nearest mm

Figure 5



The test was repeated three more times using the same hand to catch the ruler. **Table 3** shows student **A**'s results.

Table 3

Trial	Distance the ruler has fallen / mm
1	79
2	97
3	10
4	94

The student was able to convert these distances into reaction times using **Table 4**.

Table 4

Distance the ruler fell / mm	Reaction time / ms
10	45
20	64
30	78
40	90
50	101
60	111
70	120
80	128
90	136

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0 2 . 2 Calculate the percentage uncertainty in the measurement of **Trial 1** in **Table 3**.

Put a tick (✓) in the correct box below.

[1 mark]

0.633% ☐

1.27% ☐

2.53% ☐

12.6% ☐

0 2 . 3 In this investigation, it is not possible for a student to react in less than 45 ms

Suggest **one** explanation for the value recorded in **Trial 3** in **Table 3**.

[1 mark]

_____

_____

_____

0 2 . 4 Student **A** estimated that the length of the nerve pathway involved was 175 cm

Use **Table 3** and **Table 4** to calculate the mean speed of nerve impulse transmission.

Do **not** use the value for **Trial 3** in your calculation.

[2 marks]

Answer _____ m s^{-1}

Question 2 continues on the next page

Do not write outside the box

0 2 . 5 In response to touch, nerve impulses can be transmitted at speeds of 76.2 m s^{-1}

Suggest **three** reasons why, in this investigation, the estimated speed of student **A**'s impulse transmission was less than 76.2 m s^{-1}

[3 marks]

1 _____

_____

_____

2 _____

_____

_____

3 _____

_____

_____

9

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0 3 A student prepared a stained squash of cells from the root tips of garlic to calculate a mitotic index. He:

1. cut the end 5 mm from 10 garlic roots
2. placed the root tips into a Petri dish containing 5 cm^3 of hydrochloric acid for 12 minutes
3. rinsed the root tips in distilled water
4. placed one of the root tips on a microscope slide and added toluidine blue stain
5. placed a coverslip onto the microscope slide, and gently pressed the coverslip downwards on the root tip
6. observed the root tip using an optical microscope.

0 3 . 1 Suggest why the student soaked the root tips in hydrochloric acid in step **2**.

[2 marks]

0 3 . 2 Pressing the coverslip downwards enabled the student to observe the stages of mitosis clearly.

Explain why.

[2 marks]

Question 3 continues on the next page

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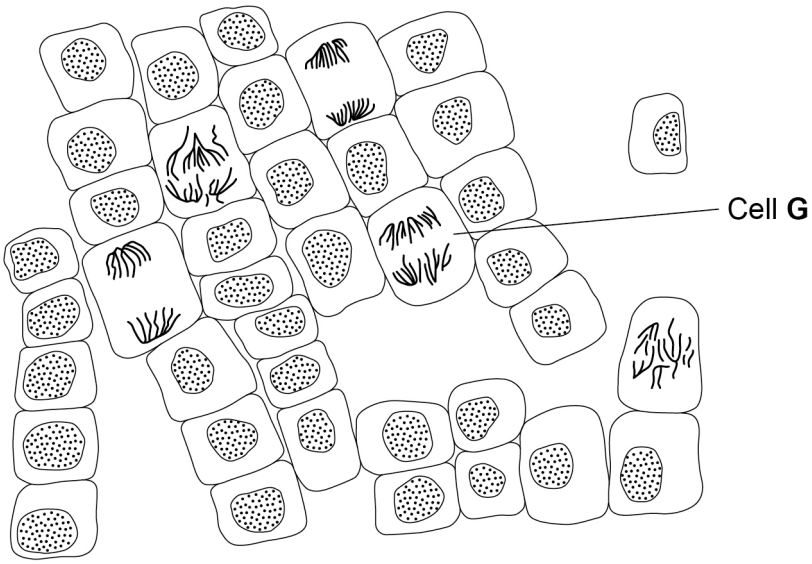
Figure 6 shows the student's drawing of one field of view.

Figure 6



0 3 . 3 Name the stage of mitosis shown in cell **G**. Explain the appearance of this cell.

[2 marks]

Stage of mitosis _____

Explanation _____

_____

_____

_____

_____

0 3 . 4 Use **Figure 6** to calculate a mitotic index for the cells in this field of view.

[1 mark]

Mitotic index _____

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0 3 . 5 Other students in the class followed the same method, but calculated different mitotic indices.

Apart from student errors, suggest **two** explanations why.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

9

Turn over for the next question

Do not write outside the box

0 4 . 1 Complete the following definitions.

[2 marks]

The genome is _____

_____

_____

The proteome is _____

_____

_____

Recombinant DNA technology can involve the transfer of fragments of human DNA into bacteria. The bacteria are then used to produce human proteins.

0 4 . 2 Give **two** reasons why bacteria are able to use human DNA to produce human proteins.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

0 4 . 3 Suggest and explain **one** reason why bacteria might **not** be able to produce every human protein.

[1 mark]

_____

_____

_____

_____

_____

_____

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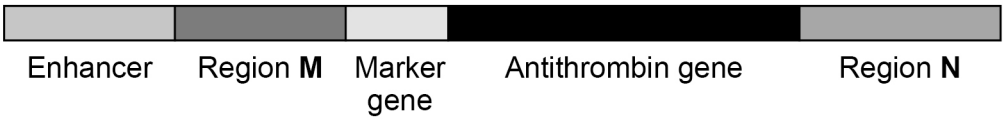
Antithrombin is a protein. Antithrombin prevents blood from clotting too much.

Some people have a deficiency of antithrombin in their blood, so they need to inject the protein.

Genetically modified goats are used to produce this protein. The human antithrombin gene is transferred into goat embryos. The adult goats then make human antithrombin protein.

Figure 7 shows an example of a DNA fragment that can be transferred into the cells of goats.

Figure 7



0 4 . 4 The enhancer stimulates region **M**.

Name regions **M** and **N** shown in **Figure 7**.

[2 marks]

Region **M** _____

Region **N** _____

0 4 . 5 Explain the purpose of the marker gene.

[1 mark]

_____

_____

0 4 . 6 The enhancer only stimulates region **M** in the milk-producing glands of a goat.

Suggest **two** explanations for the importance of the enhancer being included in the DNA fragment transferred.

[2 marks]

1 _____

_____

_____

_____

2 _____

_____

_____

_____

10

Turn over ►

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0 5 Scientists investigated the effect of full sun and shade on the rate of photosynthesis in a species of shade-tolerant tree.

To estimate the rate of photosynthesis, the scientists measured uptake of carbon dioxide by trees in a forest. They measured uptake of carbon dioxide during two parts of the day:

- 08.30 – 09.40 hours
- 11.40 – 13.15 hours.

Figure 8 shows the scientists' results.

Figure 8

Figure 8 not reproduced here due to third-party copyright restrictions

0 5 . 1 Calculate the total uptake of carbon dioxide between 11.40 and 13.15 hours in trees exposed to full sun in a forest that is 12 000 m^2 in area.

Give your answer in standard form. Show your working.

[3 marks]

Answer _____ μmol

Do not write outside the box

0 5 . 2 **Figure 8** shows there is a small difference in the mean uptake of carbon dioxide between 08.30 and 09.40 hours by trees in full sun and by trees in the shade. When the scientists performed a statistical test on these data, they calculated $P > 0.5$

State what this P value tells you about this difference.

Explain your answer using the words **probability** and **chance**.

[2 marks]

0 5 . 3 In this species of tree, very high light intensities can inhibit the release of electrons from chlorophyll.

Suggest how this could explain the results shown in **Figure 8** for 11.40 to 13.15 hours.

[4 marks]

Question 5 continues on the next page

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Tomato plants grow best in high light intensities. To increase the yield of tomato plants, a farmer uses LED lightbulbs to provide additional light.

The increase in dry mass (D) produced when using additional light can be calculated using this equation.

$$D = \frac{L}{0.4F}$$

Where
L = light used in photosynthesis
F = GPP to NPP conversion factor for tomato plants

Table 5 shows some of these values for LED lightbulbs.

Table 5

L / MJ m^{-2} h^{-1}	**F / MJ kg^{-1}**
2.87×10^{-2}	20

0 5 . 4 Use the equation and **Table 5** to calculate the increase in dry mass produced when using LED lightbulbs.

Give your answer in standard form **and** give the units.

[2 marks]

Answer _____ Units _____

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0 5 . 5 Mature leaves from slow-growing, shade-tolerant plants produce poisonous chemicals that are a defence against being eaten by herbivores.

Suggest how this benefits slow-growing, shade-tolerant plants.

[2 marks]

Question 5 continues on the next page

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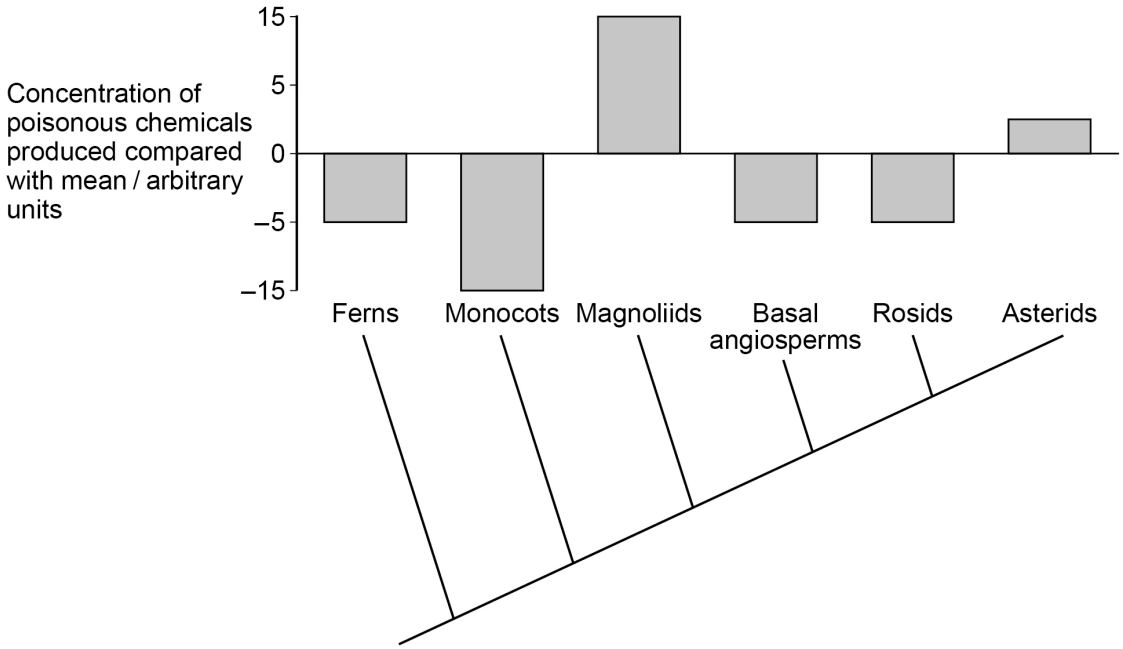
Scientists measured the concentration of poisonous chemicals produced by shade-tolerant plant species in six taxa. They compared this with the mean concentration of poisonous chemicals produced by all plants and the phylogenetic relationships between the six taxa.

Figure 9 shows the scientists' results.

Figure 9



0 5 . 6 A journalist published the following summary of these results.

'The more recently a shade-tolerant plant species evolved, the greater the concentration of poisonous chemicals it produces.'

Do the data in **Figure 9** support this summary? Justify 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 6 Write an essay on **one** of the topics below.

Either

0 6 . 1 The uses and importance of ATP in organisms.

[25 marks]

Or

0 6 . 2 The importance of cycles in biology.

[25 marks]

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25

END OF QUESTIONS

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