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 1

Thursday 10 June 2021 Afternoon 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.
- 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 91.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

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

0 1 . 1 Describe the induced-fit model of enzyme action **and** how an enzyme acts as a catalyst.

[3 marks]

0 1 . 2 Scientists investigated the action of the enzyme ATP synthase. They made reaction mixtures each containing:

- ATP synthase
- buffer (to control pH)
- substrates.

One of the substrates required in these reaction mixtures is inorganic phosphate (Pi).

Tick (✓) **one** box to show which other substrate the scientists must add to the reaction mixtures to produce ATP.

[1 mark]

Adenine ☐

Adenosine diphosphate ☐

Glucose ☐

Ribose ☐

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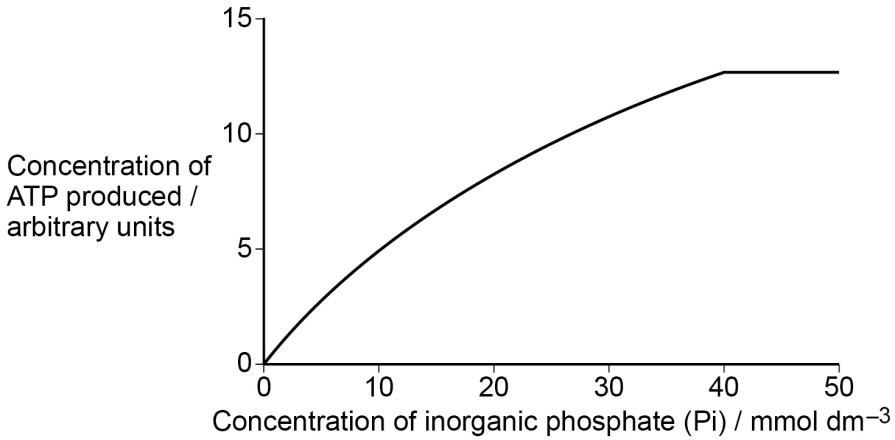
0 1 . 3 The scientists investigated the effect of concentration of inorganic phosphate (Pi) on ATP synthase activity.

After 2 minutes, they stopped each reaction and then measured the concentration of ATP.

Figure 1 shows the scientists' results.

Figure 1



Suggest and explain a procedure the scientists could have used to stop each reaction.

[2 marks]

_____

_____

_____

_____

0 1 . 4 Explain the change in ATP concentration with increasing inorganic phosphate concentration.

[2 marks]

_____

_____

_____

_____

_____

_____

8

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0 2 . 1 Explain the advantage for larger animals of having a specialised system that facilitates oxygen uptake.

[2 marks]

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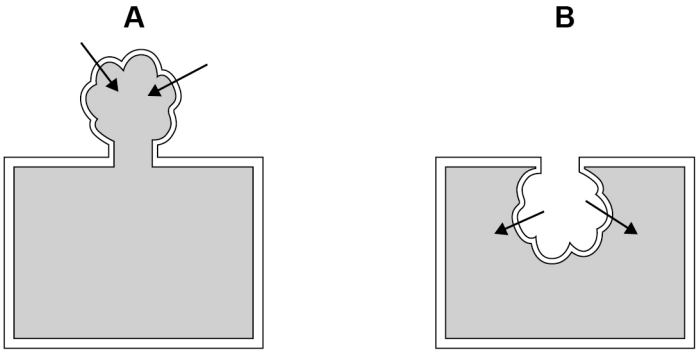
Figure 2 shows two models of oxygen uptake found in animals.

Figure 2



Oxygen uptake through system developed to the outside of the body, eg fish gills

Oxygen uptake through system developed to the inside of the body, eg human lungs

0 2 . 2 Suggest how the environmental conditions have resulted in adaptations of systems using **Model A** rather than **Model B**.

[2 marks]

Question 2 continues on the next page

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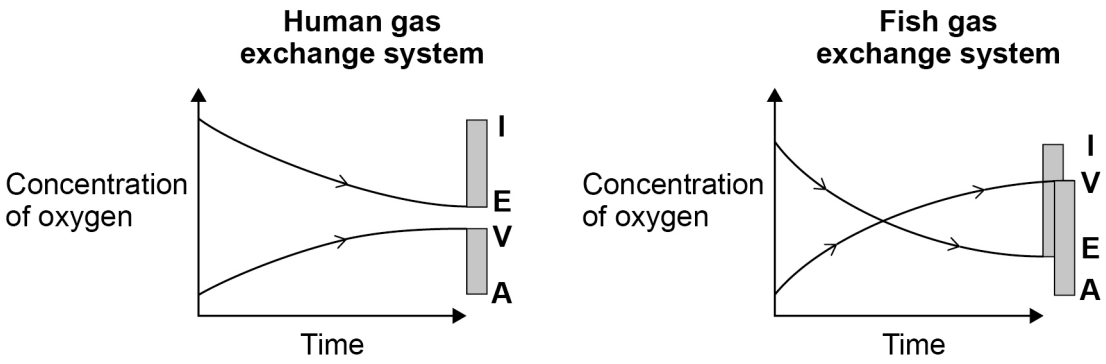
0 2 . 3 **Figure 3** shows changes in concentration of oxygen in two gas exchange systems.

Figure 3



Key

I Air/water entering the gas exchange system
E Air/water leaving the gas exchange system
A Arterial blood entering the gas exchange system
V Venous blood leaving the gas exchange system

A student studied **Figure 3** and concluded that the fish gas exchange system is more efficient than the human gas exchange system.

Use **Figure 3** to justify this conclusion.

[2 marks]

0 2 . 4 Explain how the counter-current principle allows efficient oxygen uptake in the fish gas exchange system.

[2 marks]

Do not write outside the box

0 2 . 5 **Table 1** shows features of two mammals.

Bats are flying mammals; shrews are ground-living mammals.

Table 1

Mammal	Mean body mass / kg	Mean lung volume / cm^3
Bat	0.096	12.48
Shrew	0.024	0.72

Calculate how many times the lung volume per unit of body mass of the bat is greater than that of the shrew.

Give your answer to an appropriate number of significant figures.

Give **one** suggestion to explain this difference.

[3 marks]

Answer _____

Explanation _____

_____

11

Turn over ►

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ANSWER IN THE SPACES PROVIDED

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0 3 . 1 Describe how **one** amino acid is added to a polypeptide that is being formed at a ribosome during translation.

[3 marks]

Question 3 continues on the next page

Do not write outside the box

Table 2 shows:

- mRNA codons and the amino acid coded for by each codon
- the type of bond formed by the R group of some of the amino acids.

Table 2

First base	Second base				Third base
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
					C
	Leu		Stop	Stop	A
				Trp	G
C	Leu	Pro	His	Arg	U
					C
			Gln		A
					G
A	Ile	Thr	Asn	Ser	U
					C
			Lys	Arg	A
	Met				G
G	Val	Ala	Asp	Gly	U
					C
			Glu		A
					G

Key to the type of bond formed by the R group of each amino acid

Hydrogen bonds Ionic bonds Disulfide bridges

0 3 . 2 Crystallin is a structural protein found in the human eye. An inherited disease that leads to blindness is caused by changes in properties of crystallin. The replacement of the amino acid Arg with the amino acid Gly causes these changes.

Use information in **Table 2** to suggest why this amino acid replacement changes the properties of crystallin.

[2 marks]

Do not write outside the box

0 3 . 3 The amino acid replacement of Arg with Gly is caused by a single base substitution mutation in the DNA. The non-mutant DNA triplet is TCC.

Complete **Table 3**.

Give:

- the mRNA codon complementary to the non-mutant DNA triplet
- the mutated mRNA codon that could cause the change from Arg to Gly in the crystallin protein
- the DNA triplet complementary to this mutated mRNA codon.

[2 marks]

Table 3

mRNA codon for the non-mutant triplet	
Mutated mRNA codon	
Mutated DNA triplet	

7

Turn over for the next question

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0 4 A student dissected an organ from a mammal to observe blood vessels.

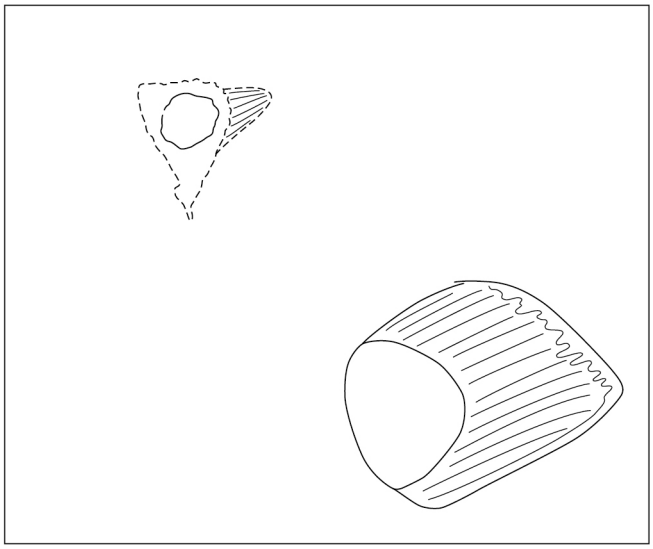
He dissected a slice of the organ and identified two blood vessels.

Figure 4 shows a photograph of his dissection.

Figure 4

Figure 5 shows a drawing of the blood vessels from his dissection.

Figure 5



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0 4 . 1 Suggest **two** ways the student could improve the quality of his scientific drawing of the blood vessels in this dissection.

[2 marks]

1 _____

_____

2 _____

_____

0 4 . 2 Identify the type of blood vessel labelled as **X** and the type of blood vessel labelled as **Y** in **Figure 4**.

Describe **one** feature that allowed you to identify the blood vessels.

[2 marks]

Blood vessel **X** _____

Blood vessel **Y** _____

Feature _____

_____

0 4 . 3 Describe **two** precautions the student should take when clearing away after the dissection.

[2 marks]

1 _____

_____

2 _____

_____

6

Do not write outside the box

0 5 . 1 Describe how a sample of chloroplasts could be isolated from leaves.

[4 marks]

Do not write outside the box

0 5 . 2 Scientists grew two groups of plants:

- control plants with all the inorganic ions needed
- iron-deficient plants with all the inorganic ions needed **but** without iron ions.

After 1 week, the scientists measured the mass of protein and the mass of chlorophyll in the chloroplasts isolated from samples of leaves of these two groups of plants.

Table 4 shows the scientists' results.

Table 4

Mass of protein / percentage of control	Mass of chlorophyll / percentage of control
40	10

Some proteins found inside the chloroplast are synthesised inside the chloroplast.

Give **one** feature of the chloroplast that allows protein to be synthesised inside the chloroplast **and** describe **one** difference between this feature in the chloroplast and similar features in the rest of the cell.

[2 marks]

Feature _____

Structural difference _____

_____

0 5 . 3 The ratio of protein to chlorophyll in control plants is 9:1

Use the information in **Table 4** to calculate the ratio of protein to chlorophyll in iron-deficient plants.

[1 mark]

Ratio _____

Question 5 continues on the next page

Do not write outside the box

0 5 . 4 The scientists also observed the chloroplasts from the samples of leaves using an electron microscope.

Figure 6 shows a chloroplast from a control plant (image **A**) and a chloroplast from an iron-deficient plant (image **B**).

Figure 6

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Use **Figure 6** to suggest why iron-deficient plants have a reduced growth rate.

[3 marks]

10

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Turn over for the next question

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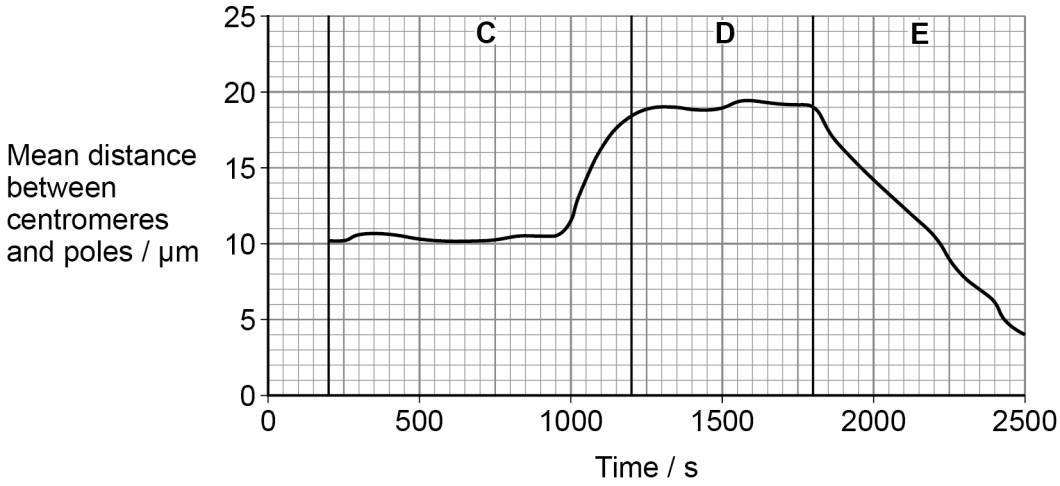
0 6 . 1 **Figure 7** shows the mean distance between centromeres and the poles (ends) of the spindle during mitosis.

Figure 7



Calculate the rate of movement of the centromeres during phase **E**.

Give your answer in µm minute^{-1} **and** to 3 decimal places.

[2 marks]

_____ µm minute^{-1}

Do not write outside the box

0 6 . 2 Name the three phases of mitosis shown by **C**, **D** and **E** on **Figure 7**.

Describe the role of the spindle fibres and the behaviour of the chromosomes during each of these phases.

[5 marks]

C _____

D _____

E _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

7

Turn over for the next question

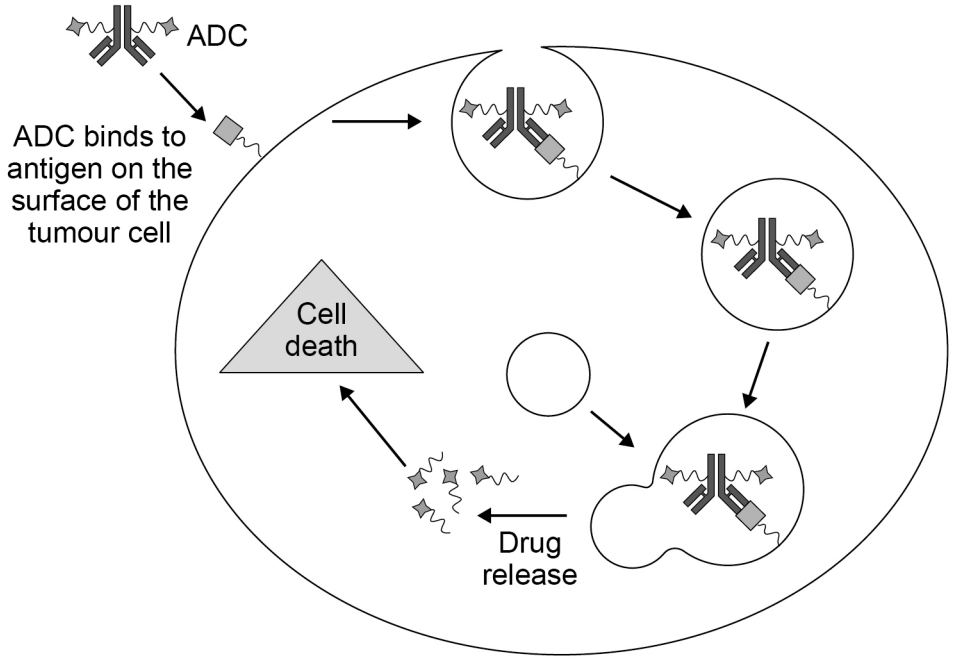
Do not write outside the box

0 7 . 1 ADCs are molecules made of a monoclonal antibody linked to a cancer drug.

Figure 8 shows how an ADC enters and kills a tumour cell.

The process of entering the cell and the breakdown of the antibody to release the drug is very similar to phagocytosis.

Figure 8



Use your knowledge of phagocytosis to describe how an ADC enters and kills the tumour cell.

[3 marks]

Do not write outside the box

0 7 . 2 Some of the antigens found on the surface of tumour cells are also found on the surface of healthy human cells.

Use this information to explain why treatment with an ADC often causes side effects.

[2 marks]

Question 7 continues on the next page

Do not write outside the box

Scientists investigated whether one type of ADC could be used to treat human breast cancer.

This ADC is a monoclonal antibody combined with a drug to inhibit mitosis. The monoclonal antibody binds to a protein found on human breast cancer cells.

The scientists placed small pieces of human breast cancer tissue under the skin of mice.

The scientists then randomly divided the mice into three groups. They treated the groups as follows on day 0.

Group G – control
Group H – injected with monoclonal antibody only
Group J – injected with ADC (monoclonal antibody + drug).

Every few days, the scientists measured the volume of the tumours formed from the human breast cancer tissue.

Figure 9 shows the scientists' results.

Figure 9

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Do not write outside the box

0 7 . 3 Mice in **Group H** were injected with 2 mg kg^{-1} of monoclonal antibody.
The monoclonal antibody was in a solution of concentration 500 mg dm^{-3}

Calculate the volume of antibody solution that the scientists would have injected into a 23 g mouse. Give your answer in dm^3 and in standard form.

[2 marks]

_____ dm^3

0 7 . 4 Suggest **one** reason why there are no data for **Group G** and **Group H** after day 8

[1 mark]

_____

_____

_____

0 7 . 5 Suggest and explain **two** further investigations that should be done before this ADC is tested on human breast cancer patients.

[2 marks]

1 _____

_____

2 _____

_____

10

Turn over for the next question

Do not write outside the box

0 8 . 1 Describe how a triglyceride molecule is formed.

[3 marks]

Do not write outside the box

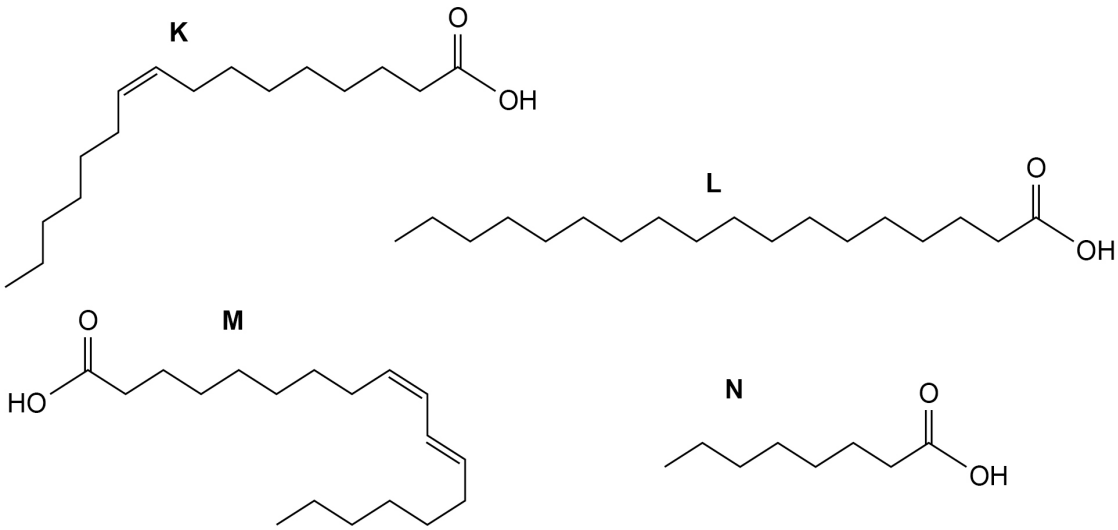
0 8 . 2 **Table 5** shows some properties of four fatty acids.

Table 5

Fatty acid	Number of carbon atoms in the R group	Number of double bonds in the R group
Caprylic acid	8	0
Palmitoleic acid	16	1
Stearic acid	18	0
Linoleic acid	18	2

Figure 10 shows diagrams of these fatty acids.

Figure 10



Put a tick (✓) in **one** box that contains correct information about one of these fatty acids.

[1 mark]

Caprylic acid is an unsaturated fatty acid represented by diagram **L**. ☐

Linoleic acid is a saturated fatty acid represented by diagram **N**. ☐

Palmitoleic acid is an unsaturated fatty acid represented by diagram **K**. ☐

Stearic acid is a saturated fatty acid represented by diagram **M**. ☐

Do not write outside the box

The percentage of saturated fatty acids compared with unsaturated fatty acids found in lipid stores in seeds differs in different populations.

Scientists investigated two populations of the plant, *Helianthus annuus*.

The scientists grew young plants from seeds collected from each population. They placed the seeds on wet tissue paper so that the root growth was visible.

They grew seeds from each population at two temperatures:

- warm temperature of 24 °C
- cool temperature of 10 °C

After 10 days, the scientists measured the length of each root.

Table 6 shows some of the properties of the two populations and the scientists' results.

Table 6

Population	Temperature in natural environment	In the seed – Mean percentage of fatty acids that are saturated	Mean length of root after 10 days at 24 °C / mm (± 2 x standard deviation)	Mean length of root after 10 days at 10 °C / mm (± 2 x standard deviation)
1	Warm	10.9	8.2 (±1.0)	3.1 (±0.3)
2	Cool	6.1	5.5 (±0.9)	4.3 (±0.2)

The mean ±2 × standard deviation includes 95% of the data.

0 8 . 3 The scientists used a data logger to measure the length of the root rather than a ruler.

Suggest **one** reason why they used a data logger **and** explain why this was important in this investigation.

[1 mark]

Do not write outside the box

0 8 . 4 It is known that:

- during respiration saturated fatty acids yield more energy than unsaturated fatty acids
- saturated fatty acids have higher melting points than unsaturated fatty acids
- lipases in seeds act more rapidly on liquid substrates.

Use this information and **Table 6** to show how each population is better adapted for its natural environment when compared with the other population.

[4 marks]

0 8 . 5 Although these two populations are completely separate and show genetic variation, they are both called *Helianthus annuus*.

Explain why they are both given this name.

[1 mark]

10

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ANSWER IN THE SPACES PROVIDED

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0 9 . 1 Complete **Table 7** with ticks (✓) to show which elements are found in the following biological molecules.

[2 marks]

Table 7

Biological molecules	**Element**			
	Carbon	Nitrogen	Oxygen	Phosphorus
Galactose				
Phospholipid				
RNA				
Sucrose				

Question 9 continues on the next page

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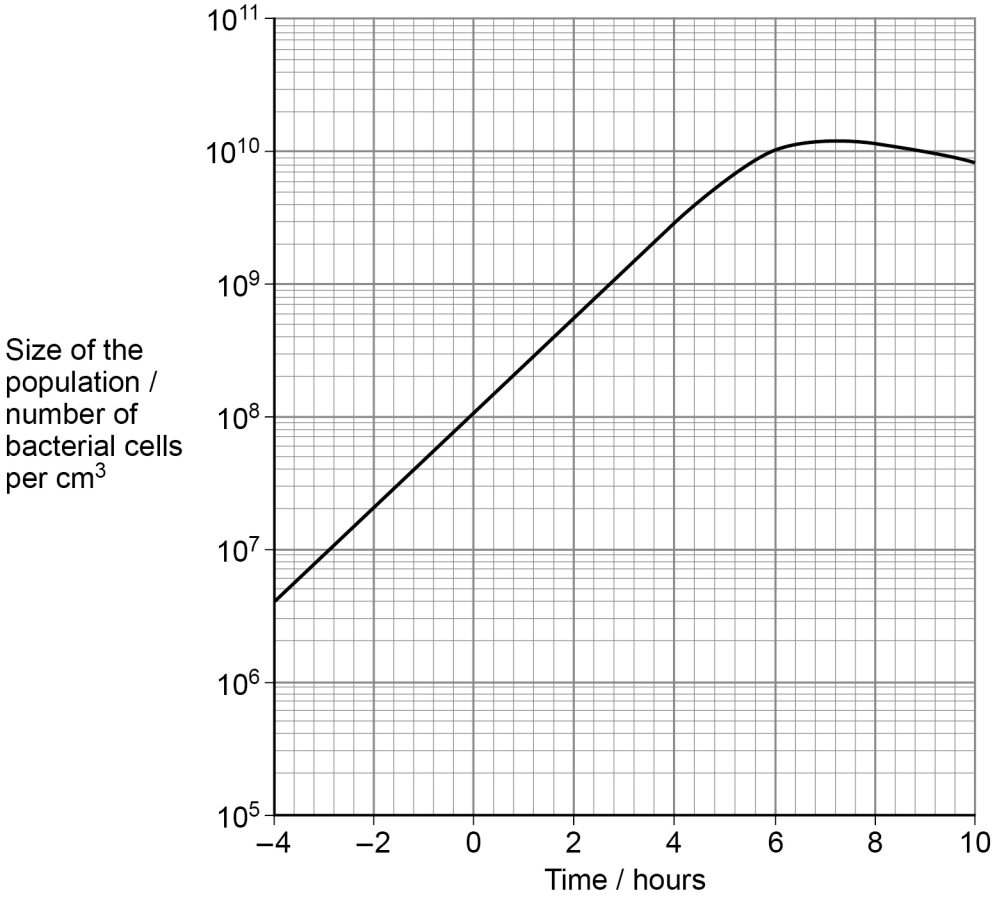
After Watson and Crick proposed the model of DNA structure, scientists investigated the possible mechanisms for DNA replication.

Two scientists grew a bacterial population, providing them with a nitrogen source containing only the heavy isotope of nitrogen, ^{15}N. As soon as all the DNA in this population contained ^{15}N, the scientists changed the nitrogen source to one containing only the lighter isotope of nitrogen, ^{14}N. They changed the nitrogen source at 0 hours.

During the investigation, the scientists measured the size of the population of bacterial cells.

Figure 11 shows the scientists' results.

Figure 11



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0 9 . 2 The generation time for a population of bacteria is the time taken for all the bacteria to divide once by binary fission.

Use **Figure 11** and the following equation to calculate the generation time for this population of bacteria. Give your answer in hours.

[2 marks]

$$\text{Number of generations} = \frac{\log_{10}\left(\dfrac{\text{size of population at time } +4 \text{ hours}}{\text{size of population at time } -4 \text{ hours}}\right)}{\log_{10} 2}$$

Generation time _____ hours

Question 9 continues on the next page

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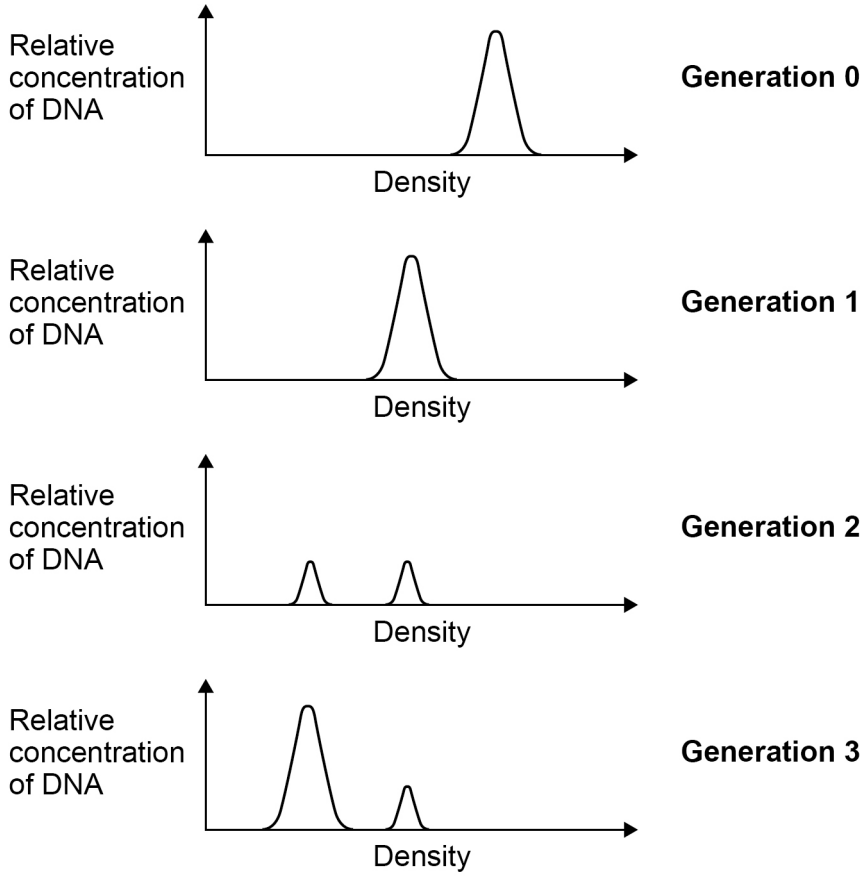
At intervals during this investigation, the scientists removed samples of the bacterial population, isolated the DNA and measured the density of the DNA.

DNA made using ^{15}N has a higher density than DNA made using ^{14}N.

Figure 12 shows the scientists' results.

Figure 12



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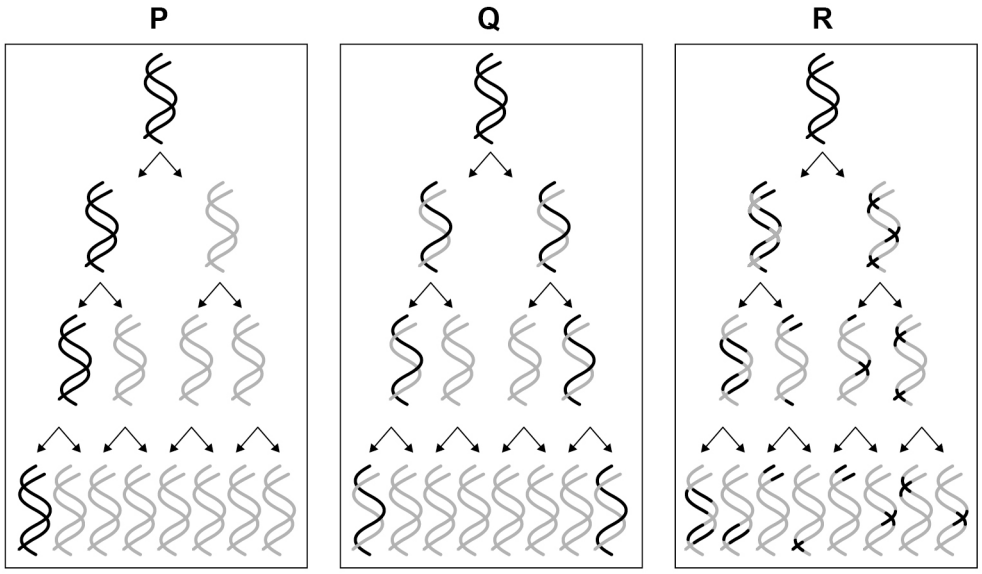
There are **three** possible models of DNA replication.

These models are shown in **Figure 13**.

Figure 13



0 9 . 3 Which of these models, **P**, **Q** or **R**, is supported by the results shown in **Figure 12**?

Give the letter and name of the model supported and explain why the results do **not** support the other models.

[3 marks]

Model _____

Name _____

Explanation for first **unsupported** model _____

_____

Explanation for second **unsupported** model _____

_____

7

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1 0 . 1 Describe the structure of DNA.

[5 marks]

Do not write outside the box

1 0 . 2 Name **and** describe **five** ways substances can move across the cell-surface membrane into a cell.

[5 marks]

Question 10 continues on the next page

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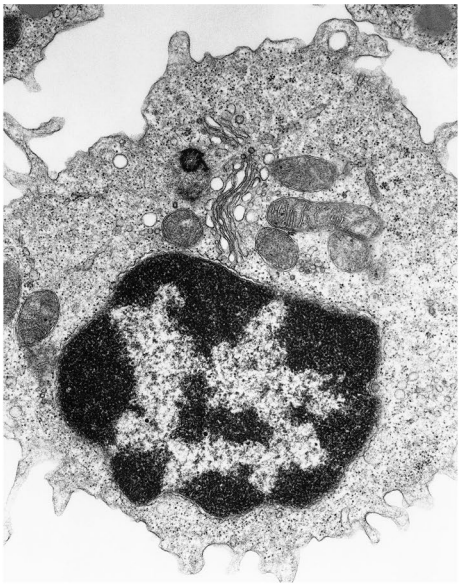
Figure 14 shows transmission electron micrographs of two cells, one animal cell and one prokaryotic cell.

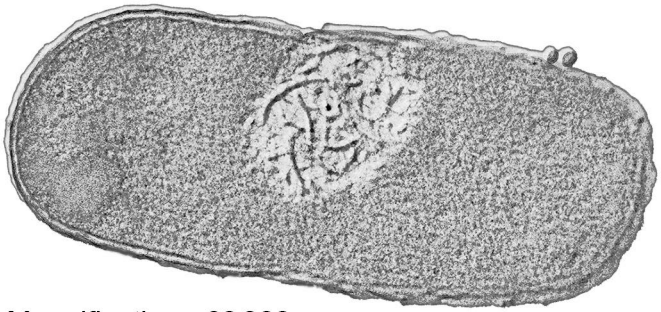
Figure 14

Cell A



Magnification ×30 000

Cell B



Magnification ×60 000

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1 0 . 3 Contrast the structure of the two cells visible in the electron micrographs shown in **Figure 14**.

[5 marks]

15

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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