AQA

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	

Do not write outside the box

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]

The substrate binds to the active site of the enzyme. When this happens the active site of the enzyme changes shape to become complementary to the substrate. It works as a catalyst by not being used up in the reaction, but increasing its rate by reducing the amount of activation energy needed to have the reaction take place..

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	☐

ADP + Pi → ATP

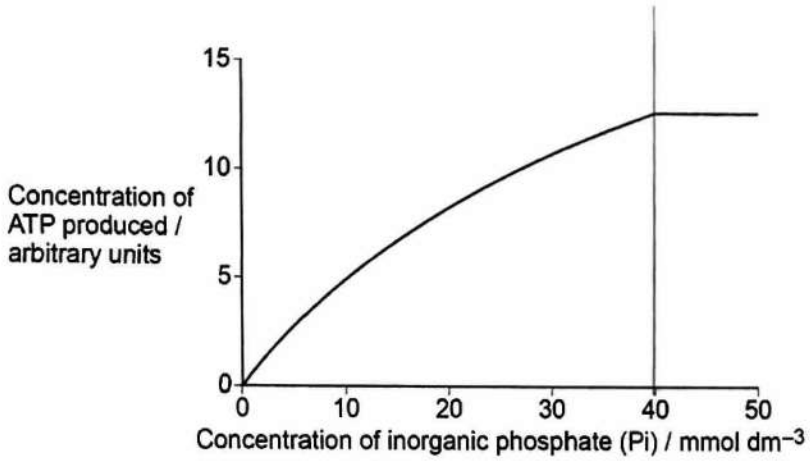
Do not write outside the box

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]

Boil reactions in the tube. This high heat will denature the ~~enzyme~~ enzymes ATP synthase stopping the reaction.

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

[2 marks]

As Pi concentration is increased so does the concentration of ATP produced increases. However, only up to about 40 mmol dm^{-3}, above this no further increase is observed. This is because before 40 mmol dm^{-3} Pi concentration was the limiting factor to enzyme substrate complexes forming. After 40 mmol dm^{-3} the enzyme becomes the limiting factor.

8

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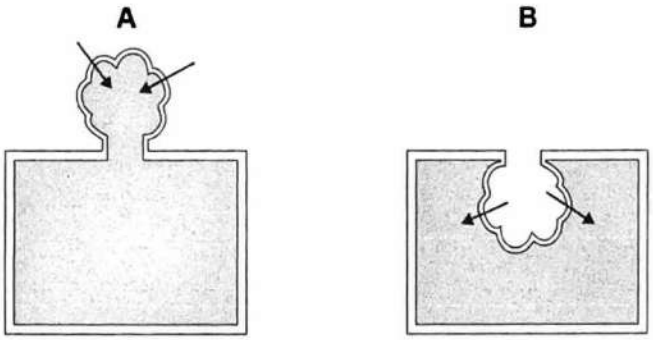
0 2 . 1 Explain the advantage for larger animals of having a specialised system that facilitates oxygen uptake.

[2 marks]

Larger animals have a small surface area to volume ratio. Therefore, diffusion is slow ~~and~~ to some parts of the body as the diffusion pathway is long. By having a specialised system it can be done more efficiently and make sure enough oxygen is supplied to cells.

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**.

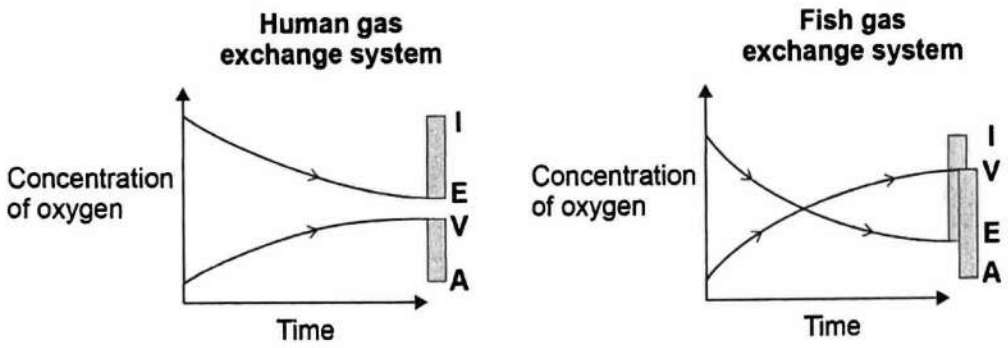
[2 marks]

Water has a significantly ~~higher~~ lower oxygen concentration than air. So, for fish having an external structure provides a larger surface area to be in contact with water, as it moves past it.

Question 2 continues on the next page

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]

In fish V is higher than E, so more oxygen is in the blood than water leaving the system. However, in humans E is higher than V, so more oxygen is in the air leaving than in the blood leaving. Fish remove a larger proportion of oxygen from water than we do with our lungs from air.

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

[2 marks]

In counter current exchange blood flows in the opposite direction to the direction of water flow. Diffusion gradient therefore is maintained along the whole length of the lamella, the exchange surface.

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]

Bat

$\div 0.096$ ($0.096\,kg - 12.48\,cm^3$; $1\,kg - 130\,cm^3$) $\div 0.096$ 1kg to $130\,cm^3$

Shrew

$\div 0.024$ ($0.024\,kg - 0.72\,cm^3$; $1\,kg - 30\,cm^3$) $\div 0.024$ 1 kg to $30\,cm^3$

$$\frac{130\ cm\ kg^{-1}}{30\ cm\ kg^{-1}} = 4.333333..$$

$$\Rightarrow 4.3$$

Answer 4.3

Explanation The bat needs more energy released from respiration to fly, so needs a better supply of oxygen.

11

Turn over ▶

Do not write outside the box

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

[3 marks]

Ribosomes are bond to the mRNA reading it in triplet codes called a codon. tRNA ~~bo~~ molecules bind to a specific amino acids and bring it to the ribosome. The anticodon on the tRNA molecule is complementary to the codon on the mRNA molecule binding to it. This brings the amino acid attached to the same tRNA molecule to the proximity of the already formed polypeptide chain, so it can easily be joiene on to the end of it through a condensation reaction forming a peptide bond.

Question 3 continues on the next page

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
	Met		Lys	Arg	A
					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]

Arg forms ionic bonds, while Gly forms hydrogen bonds. This means different bonds will form as protein is folded causing changes to the shape of the protein. So it will have a different tertiary structure, so potentially different properties.

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	AGG
Mutated mRNA codon	GGG
Mutated DNA triplet	CCC

7

Turn over for the next question

Do not write outside the box

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

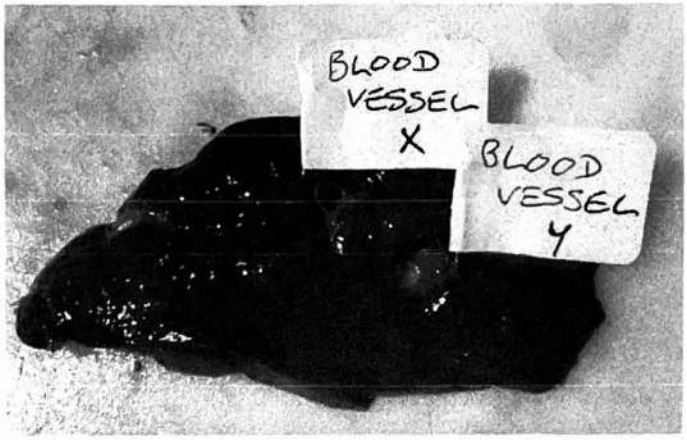
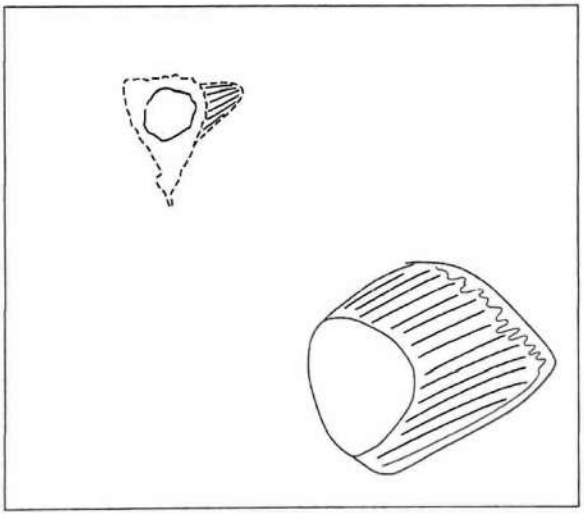


Figure 5 shows a drawing of the blood vessels from his dissection.

Figure 5



Do not write outside the box

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 Anotate to their diagram labeling it with what things are.

2 Draw all parts of the diagram with the same scale.

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** artery

Blood vessel **Y** vein

Feature x has a thicker wall to the vessle

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

[2 marks]

1 Wash hands with soap and water

2 Carry and clean equipments by handles and carefully.

6

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

[4 marks]

Do not write outside the box

Cells have to be broken up as they are covered by a cell wall and a cell membrane. This can be done by grinding or blending the sample and mix with solution with same water potential and pH ~~and~~ as cells content. Centrifuge to seperate out different parts. First the larger parts of the cell need to be removed, such as cell debris and the nucleus. Then by spinning at a higher speed we can seperate out the chloroplast as it will settle out at the bottom.

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 Contains DNA

Structural difference its not associated with histones or other proteins while nuclear DNA is.

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]

Control

9 : 1

40 so for 40 protein ×40

360 : 40

Iron deficient

360 : 10

total : protein : Chlorophyll

⇒ 36 : 1

Ratio 36 : 1

Question 5 continues on the next page

Turn over ▶

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

This source has been removed due to third-party copyright restrictions.

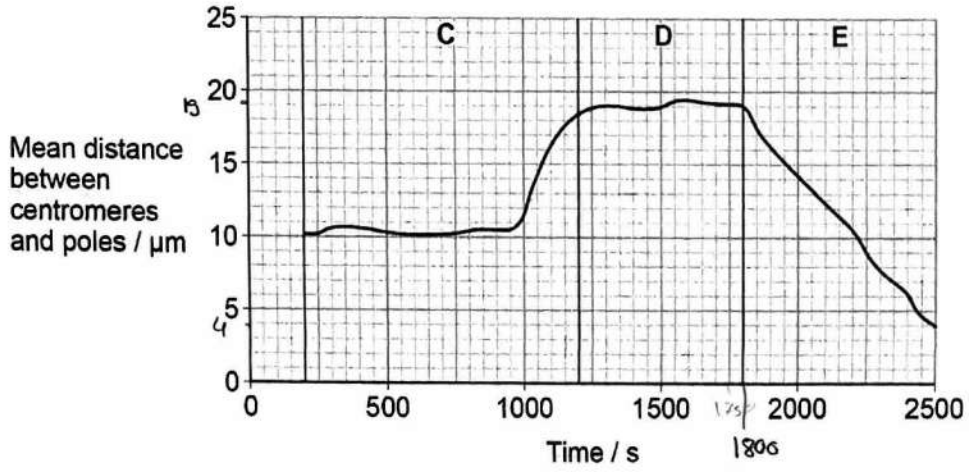
Use **Figure 6** to suggest why iron-deficient plants have a reduced growth rate.

[3 marks]

10

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]

E takes = 2500 − 1800 seconds = 700 seconds
= 11.66... min

Decreases from 19 µm to 4 µm
↳ by 15 µm

$\frac{15\,\mu m}{11.66\,min} = 1.2857...\ \mu m\ min^{-1}$
$\Rightarrow 1.286\ \mu m\ min^{-1}$

1.286 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 prophase

D metaphase

E anaphase

In prophase chromosomes condense from DNA. Also spindle fibers start to attach to the centromeres at this stage. Metaphase is when chromosomes ~~pair up~~ and align at the equator of the cell. This is followed by anaphase where the spindle fibers pull apart sister chromatids by their centromere, dividing the centromere into two. Chromatids are pulled to opposite poles of the cell. This is done by the spindle fibers shortening between the centrosomes and the centromere.

7

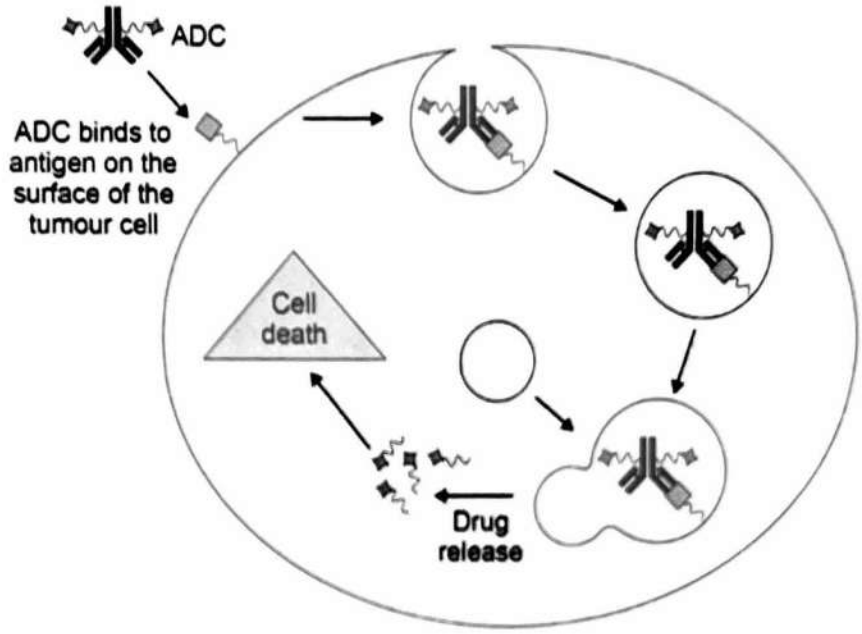
Turn over for the next question

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]

Cell engulfs the ADC by wrapping around it its cell membrane. this creates a vesicle ~~over~~ containing the ADC. This vesicle is fused with the lysosome of the cell. The lysosome breaks down the antibody but not the drug, which gets released into the cell and can cause cell death.

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]

ADC can bind to healty cells as well. Drug will be delivered in the same way into healthy cells leading to cell death to healthy cells. This causes damage to tissues and organs and organ systems.

Question 7 continues on the next page

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]

$1g = 1000mg$ $\quad 23g \Rightarrow \frac{23g}{1000} = 0.023mg$

$1kg = 1000g$ $\quad 0.023 \times 2 = 0.046mg$

$Conc = \frac{mg}{volume}$ $\quad 500\,mg\,dm^{-3} = \frac{0.046mg}{x\,dm^3}$

$x = \frac{0.046mg}{500} = 9.2 \times 10^{-5}\,dm^3$ $\quad 9.2 \times 10^{-5}$ dm^3

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

[1 mark]

All the mice could have died from the tumour.

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 Carry out the investigation at different concentrations to figure out the best dosage.

2 Test on other type of animals, mammals to see if same affect is reached.

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]

It consust of a glycerol and three fatty acid chains. These are linked by an ester bond, which is a condensation reaction removing 3 molecules of water.

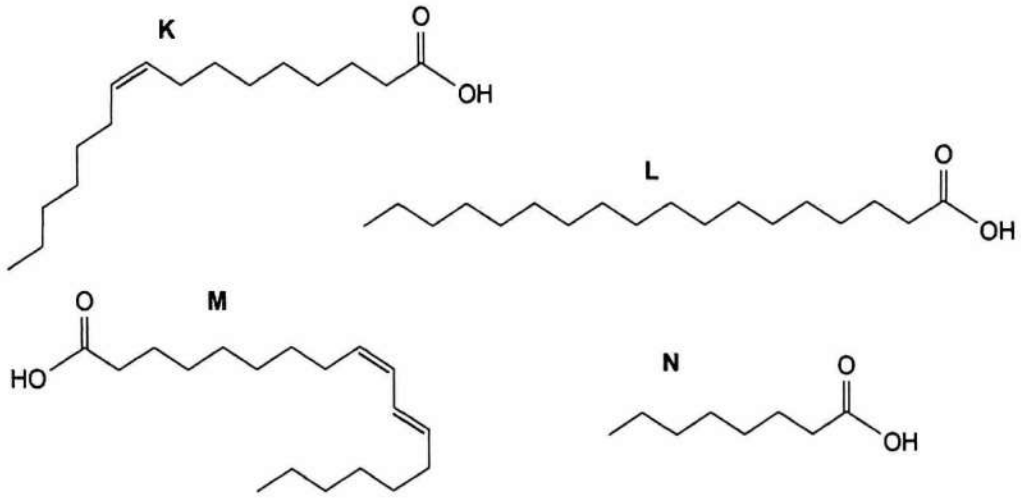
0 8 . 2 **Table 5** shows some properties of four fatty acids.

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**. ☐

Turn over ▶

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]

To increase accuracy as the length of the roots are small and ruler has lower resolution.

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]

Population 1 grew longer roots in warm temperatures, while Population 2 grew ~~longer~~ longer roots in cool temperatures. Population 1 is better adapted to warm temperatures as they have more saturated fatty acids, so more energy available so more root growth. While Population 2 is better adapted to cool temperatures as they have more unsaturated fatty acids, so more lipase activity. Standard deviations dont overlap for any of the results suggesting the differences are unlikely be due to chance.

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]

They are still the same species able to interbreed and produce fertile offspring.

10

Do not write outside the box

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

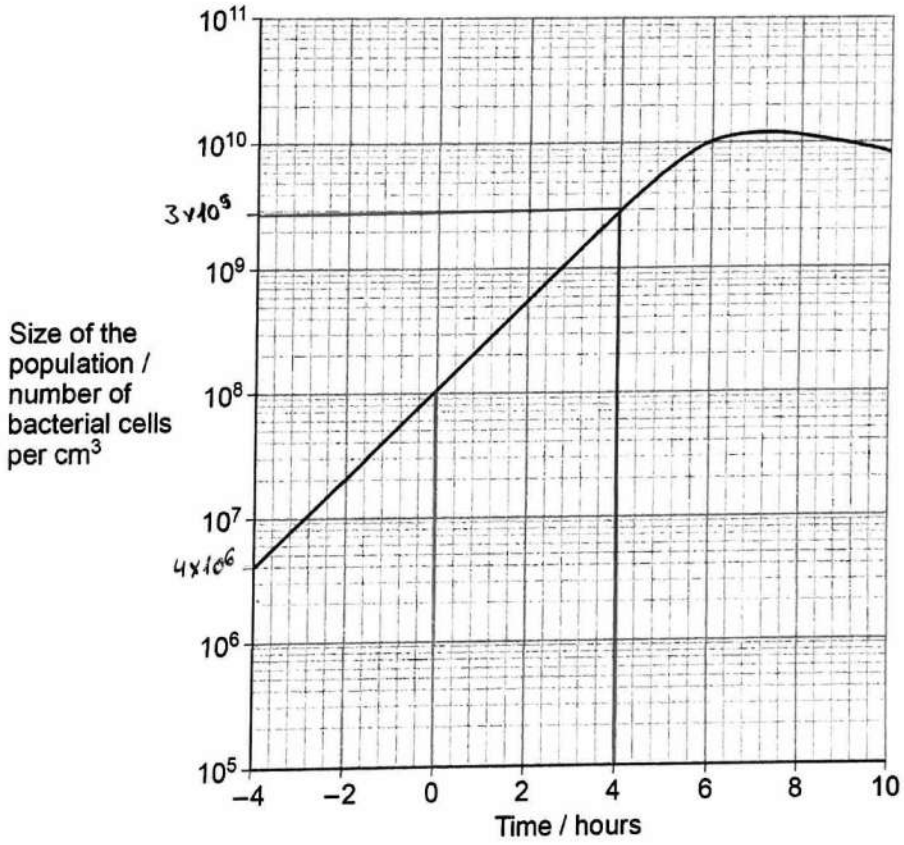
After Watson and Crick proposed the model of DNA structure, scientists investigated the possible mechanisms for DNA replication.

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



Do not write outside the box

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]

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

at −4 hours − 4×10^6 } from graph
at +4 hours − 3×10^9 }

① number of generations = $\dfrac{\log_{10}\left(\frac{3\times10^9}{4\times10^6}\right)}{\log_{10}2}$

② = $\dfrac{\log_{10}(750)}{\log_{10}2} = 9.550746\ldots$

③ $\dfrac{9.550746}{8\text{ h}} = 1.19384\ldots$

④ $\dfrac{1\text{ h}}{1.19384\ldots} = 0.837630\ldots \Rightarrow 0.84$

Generation time 0.84 hours

Question 9 continues on the next page

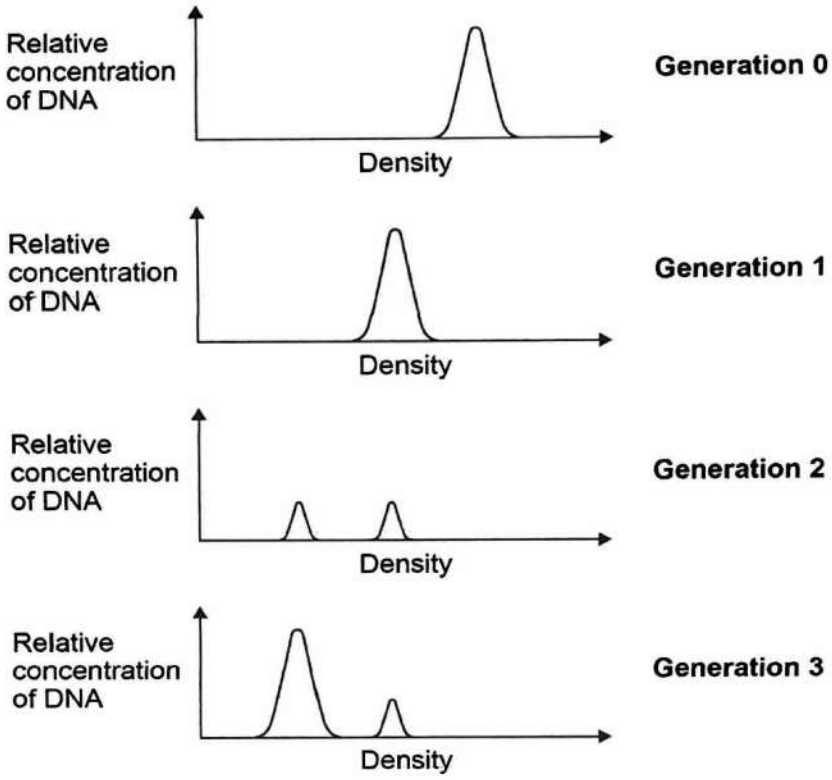
Do not write outside the box

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.

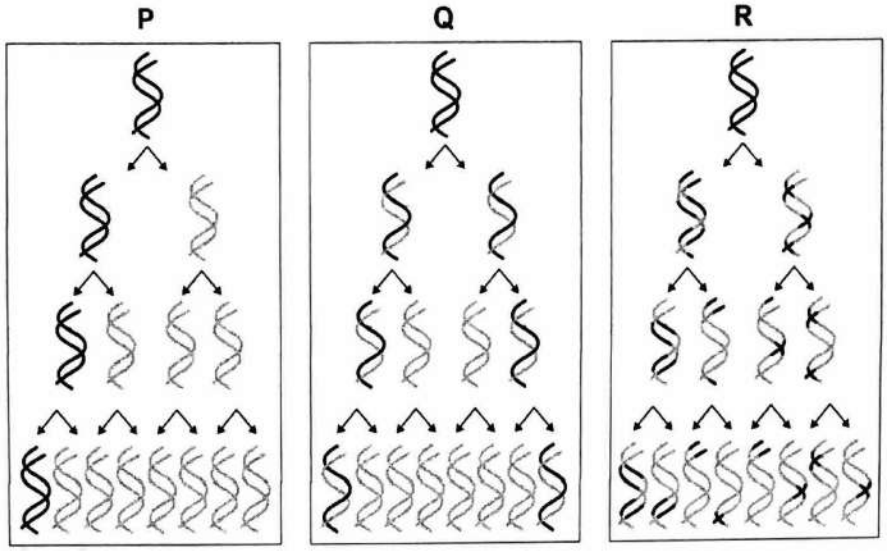
Figure 12



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 Q

Name Semi conservative replication.

Explanation for first **unsupported** model P: generation 1 should have 2 peaks as two groups with 2 types of DNA density

Explanation for second **unsupported** model R: there should be more than 2 peaks for generation 2 or generation 3.

7

1 0 . 1 Describe the structure of DNA.

[5 marks]

Do not write outside the box

DNA is a polymer of nucleotides, which are joined together by phosphodiester bonds. Two of these polymers form a double helise that is held together by hydrogen bonds between nitrogen bases.

The nucleotides consist of a deoxyribose sugar, which has a phosphate group attached, together forming the sugar phosphate backbone. There is also a nitrogen rich base attached to the deoxyribose. There are four types of bases in DNA: adenine that pairs with thymine and cytosine that pairs with guanine.

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

[5 marks]

Diffusion allows the movement of small, non-polar molecules through the membrane down a concentration gradient.

Osmosis is the movement of water into the cell through a partially permeable membrane like the cell membrane. This happens along a water potential gradient.

Facilitated diffusion allows the diffusion of substances down a concentration gradient through a carrier protein embedded into the cell membrane.

Co-transport allows the transportation of 2 different substances through the membrane by a carrier protein.

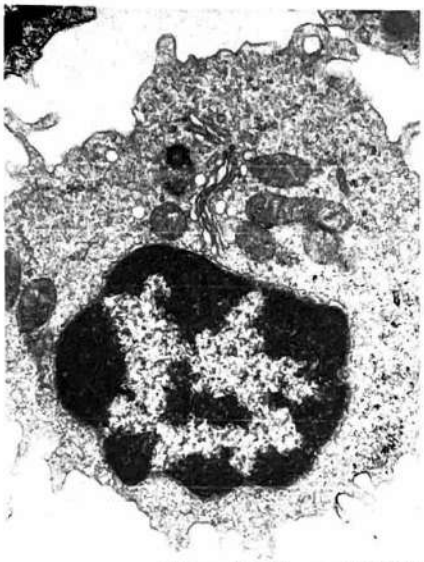
Active transport allows transport against a concentration gradient, which requires a transport protein that requires ATP.

Question 10 continues on the next page

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

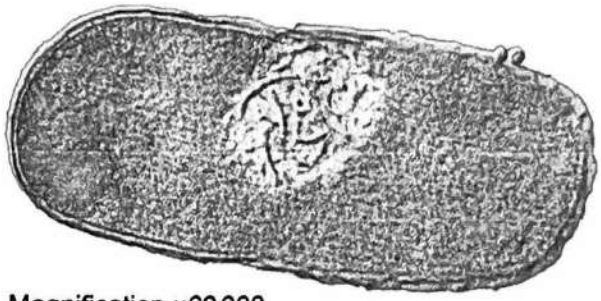
Figure 14

Cell A



Magnification ×30 000

Cell B



Magnification ×60 000

Do not write outside the box

10.3 Contrast the structure of the two cells visible in the electron micrographs shown in **Figure 14**.

[5 marks]

From the magnification size we can determine cell B is significantly smaller than A.

B does not have a membrane bound nucleus or mitochondria or an endoplasmic reticulum, these are all component cell A does have and are visible.

However, on cell B we see a cell wall as well as a cell membrane. This is a murein cell wall that cell A does not have.

15

END OF QUESTIONS