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	

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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]

The substrate binds to the active site of the enzyme. The active site changes shape slightly so it becomes more complimentary to the substrate, forming an enzyme substrate complex. This reduces the activation energy of the reaction.

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 is phosphorylated to produce ATP ie

$ADP + Pi \Rightarrow ATP$

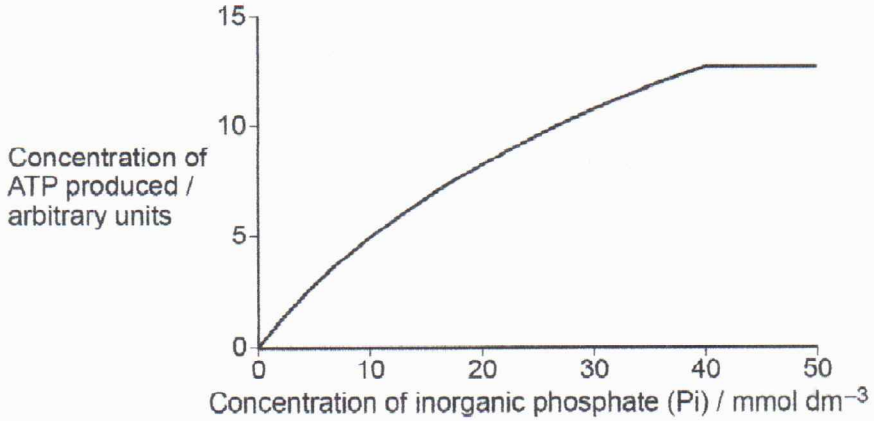
Do not write outside the box

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]

To boil the solution in order to denature the enzyme ATP Synthase. This would stop the reaction; denaturing alters the shape of the actual site so that enzyme substrate complexes stop forming, and the reaction stops.

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

[2 marks]

As the concentration of inorganic phosphate increase, the concentration of ATP produced increases; Above 40 mmol dm^{-3} there is no more increase in concentration of ATP produced. This is because all the actual sites of enzyme (ATP Synthase) are occupied. So enzyme concentration becomes limiting

8

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

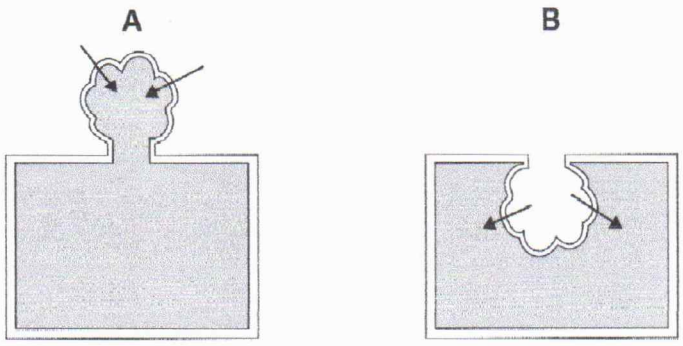
[2 marks]

larger organisms have a small surface area to volume ratio, and therefore uptake of ... would be very slow. To overcome this drawback large organisms have specialised systems that take oxygen closer to the tissues that needs it where diffusion can efficiently take place.

Do not write outside the box

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 lower partial pressure of oxygen than air. Therefore having an oxygen uptake on the outside gives a large surface area which in contact with water.

Question 2 continues on the next page

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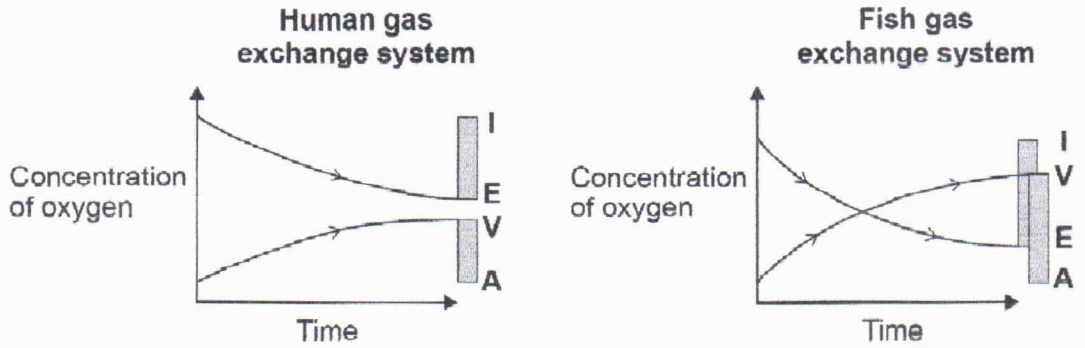
0 2 . 3 **Figure 3** shows changes in concentration of oxygen in two gas exchange systems.

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]

In fish, blood leaving (V) has more oxygen than water leaving (E), but in humans, blood leaving (V) has less oxygen than air leaving (E). difference in oxygen concentration between artery and vein is greater in fish than in humans. So fish remove a greater proportion from the oxygen they take in.

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

[2 marks]

Blood and water flows in opposite directions. Because of this a steep concentration gradient is maintained along the entire length of the filament.

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]

volume/unit body mass for bat $= \frac{12.48}{0.096} = 130$

volume/unit body mass for shrew $= \frac{0.72}{0.024} = 30$

$\therefore \frac{130}{30} = 4.3$ times

The high lung volume per unit of body mass for bat provides more oxygen for respiration. This is because the bat has a large surface area to volume ratio and therefore loss more heat to the environment it requires a higher metabolic rate to maintain its body temperature

Answer 4.3

Explanation _____

_____

11

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]

tRNA brings a specific amino acid to the ribosome. The anti-codon on tRNA binds to a codon on mRNA. The binding is by hydrogen bonds between complimentary bases on the tRNA anticodon and the mRNA codons. After binding a condensation reaction happens between the new amino acid and the one adjacent to it in the polypeptide chain and a peptide bond forms linking the two amino acid, after the peptide bond is created the tRNA pulls off and returns to the cytoplasm where it picks another amino acid.

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]

Glycine forms hydrogen bonds, while Arginine forms ionic bonds. Therefore after the changes hydrogen bonds would form instead of ionic bonds. This changes the tertiary structure of the crystallin.

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

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

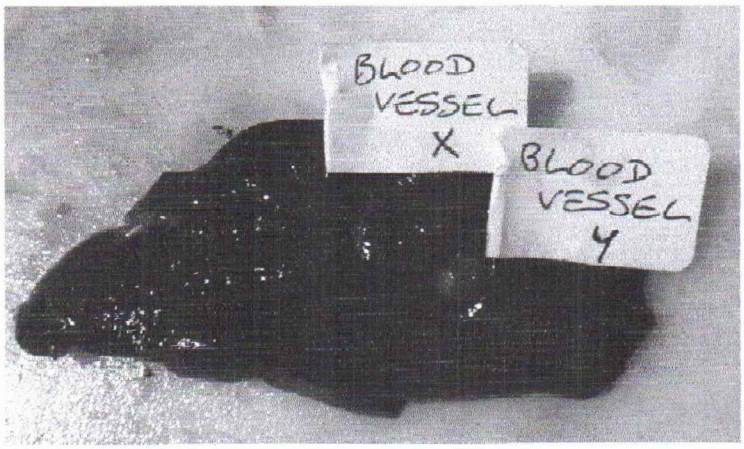
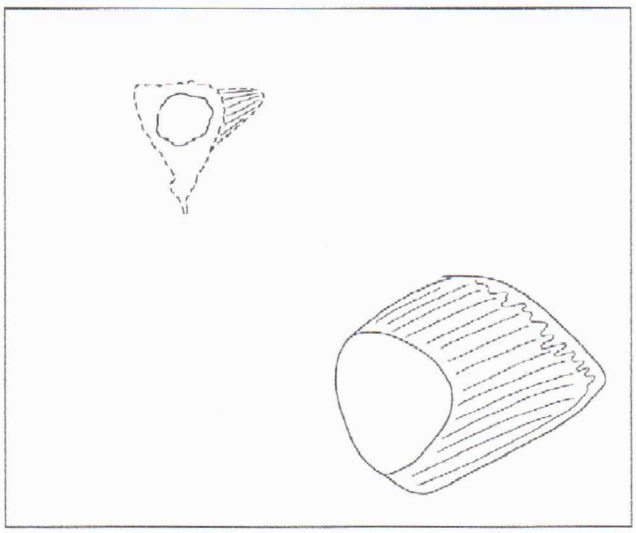


Figure 5 shows a drawing of the blood vessels from his dissection.

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 Only use single lines, and ensure lines are continous and connected.

2 Add labels.

(3) Add magnifications

(4) Draw all parts to 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 narrow lumen and Y has a wider lumen

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

[2 marks]

1 Carash sharp equipments by pointing them away from your body

2. Disinfect instruments and surfaces

3.

6

Turn over ▶

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

[4 marks]

The first step is to get leaves because within where chloroplast is found. The leaves should be ground in cold isolation buffer. This is done until the buffer begins to become green. using a filter paper pass the macerate gradually through the filter into a glass tube. The tube is centrifuged to remove unwanted whole cells and cell wall debris. The chloroplast will be in the supernatant. Therefore it's gently removed using a test pipette into another clean tube. The supernatant is then centrifuged and chloroplast will now settle out at the bottom of the centrifuge.

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 Ribosomes

Structural difference 70S ribosomes in chloroplast and 80S ribosomes in cytoplasmic ribosomes.

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]

$9 + 40 = 360$

$1 + 10 = 10$

$= 360 : 10$

$= 36 : 1$

Ratio 36:1

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

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

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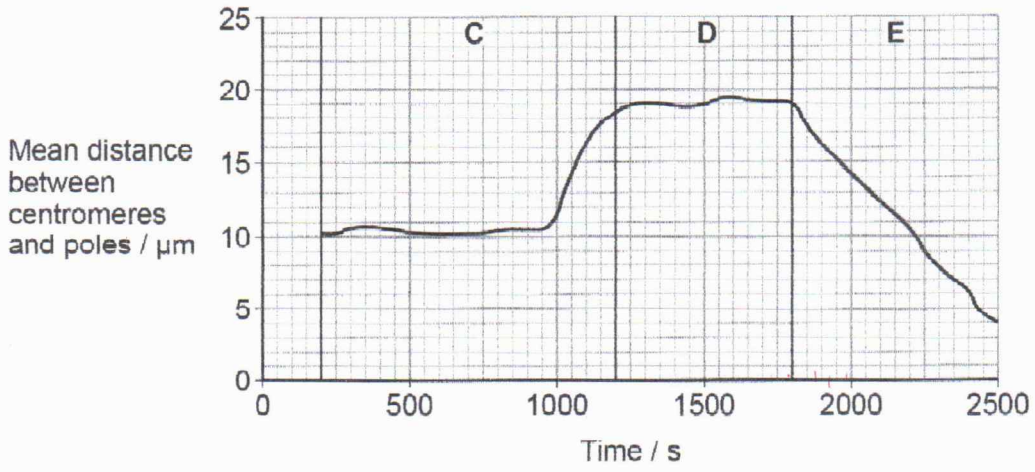
0 6 . 1 **Figure 7** shows the mean distance between centromeres and the poles (ends) of the spindle during mitosis.

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]

14 − 4 = 15 is the distance.
2500 − 1800 = 700 sec.
= 11.667 minutes.

Rate = $\frac{15}{11.667}$ = 1.286 µm 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

prophase ; chromosomes condense and becomes visible
; Spindle fibres develop from each centriole
; Nucleolus disappears and nuclear envelop breaks down.

metaphase ; chromosomes moves towards the equator of the spindle
; Here they attach to the spindle fibre by means of the centromere

Anaphase ; The centromere holding each pair of chromatid together breaks
; Free chromatids towards opposite poles centromere first.

7

Turn over for the next question

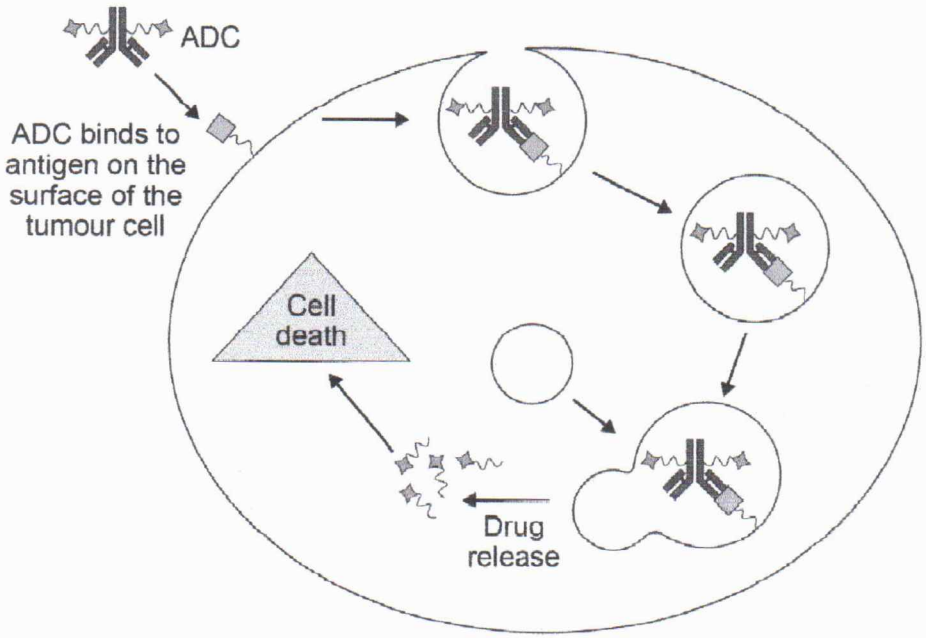
Do not write outside the box

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]

The ADC binds to antigens on the surface of the tumour cells. The cell takes in the ADC by endocytosis. The ADC gets inside in a vesicle made of the cells surface membrane of the cancer cell. Lysosome binds to the lysosome containing ADC. The lysosome releases the lytic enzyme into the phagosome. The enzymes digest the antibody and release the drug. The drug kills the cancer cell.

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]

Since antigens are found on healthy cells as well. ADC ~~edit~~ bind to healthy cells and release the drug in healthy cells This will kill healthy cells and may eventually damage tissues, organs and even 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]

_____ 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 It should be tested on other mammals eg guinea pigs to check for side effects

2 Tested on healthy humans (volunteers) to check on side effects

3 Investigate different concentrations of ADC to find suitable and safe dosage.

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]

A triglyceride is made of one glycerol molecule and three fatty acid molecules. The glycerol is linked to the three fatty acid by a condensation reaction with a release of three water molecules. An Ester bond links each fatty acid to glycerol.

Do not write outside the box

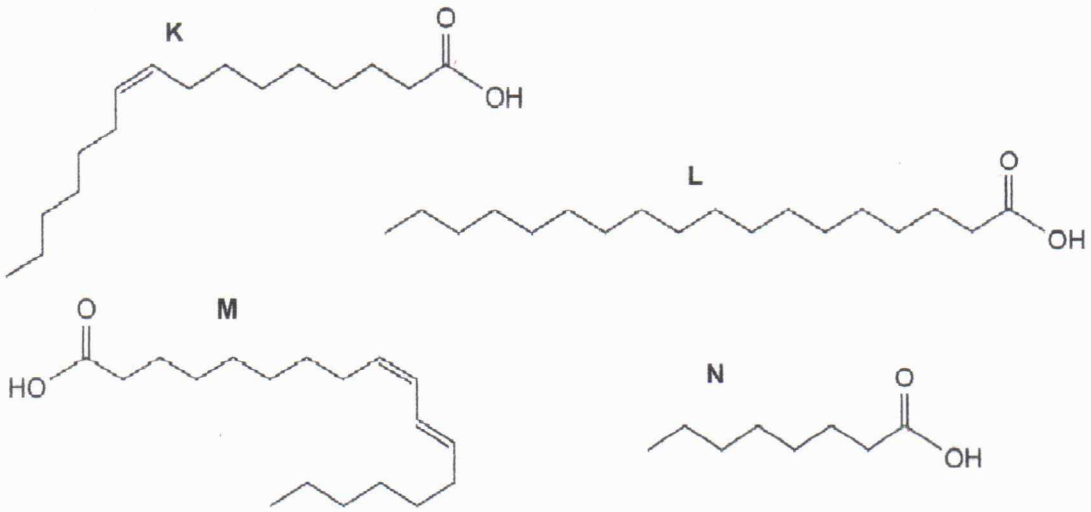
0 8 . 2 **Table 5** shows some properties of four fatty acids.

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**. ☐

L is saturated.

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

M does not have 18 carbons so it's not linoleic acid

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

K has 16 carbons and 1 double bond.

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

M has two double bonds Stearic acid has no double bonds.

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]

By using a data logger accuracy is increased because the difference in length are small than when a ruler is used. At the same time parts are less likely to be damaged by true use of a data logger.

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 roots in cool temperatures. The standard deviation do not overlap and this shows that the difference were unlikely to have occured by chance. At the same time population 1 has more saturated fatty acids indicating more growth in warm temperature this means it's better adapted for warm temperatures. Population two has more unsaturated fats acids in cool temperature indicating a better adaptation to cold temperatures

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 belong to the same species and can therefore naturally breed to produce fertile offspring.

10

Turn over ▶

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

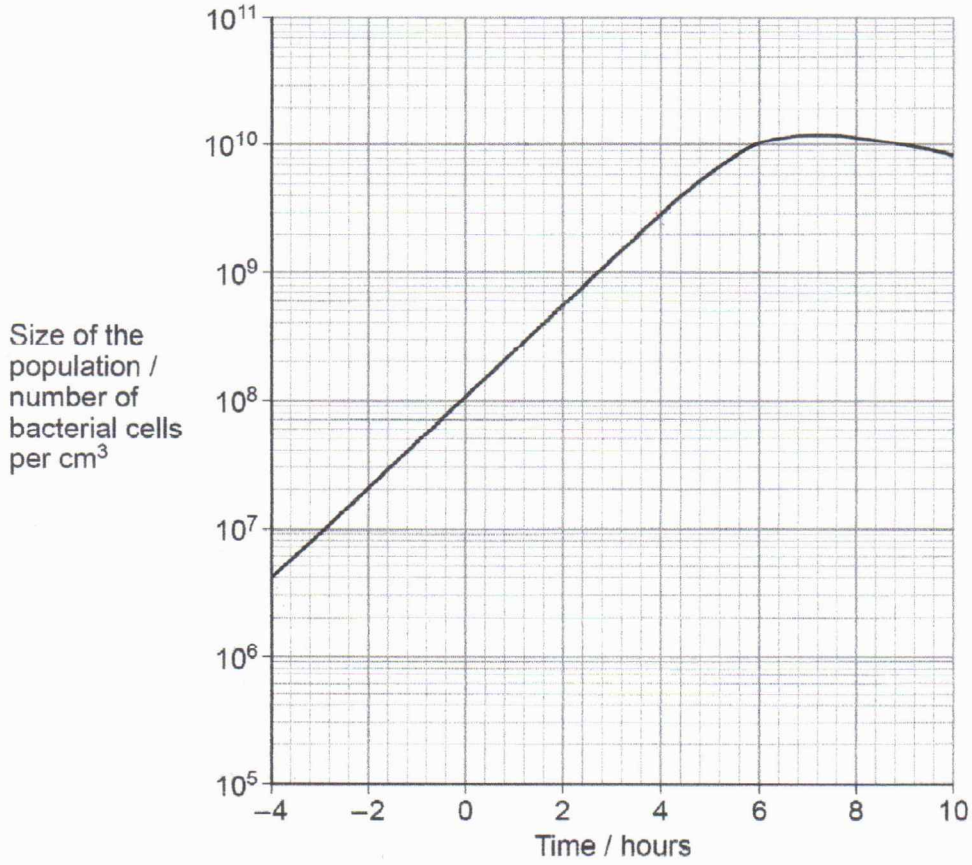
After Watson and Crick proposed the model of DNA structure, scientists investigated the possible mechanisms for DNA replication.

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]

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

Number of gene : $\log\left(\frac{10^9 + 27,000,000}{10^6 + 3,600,000}\right)$

$= \log\left(\frac{1,002,700,000}{4,600,000}\right)$

$= \log(27.98)$

$= 2.34$

Generation time 2.34 hours

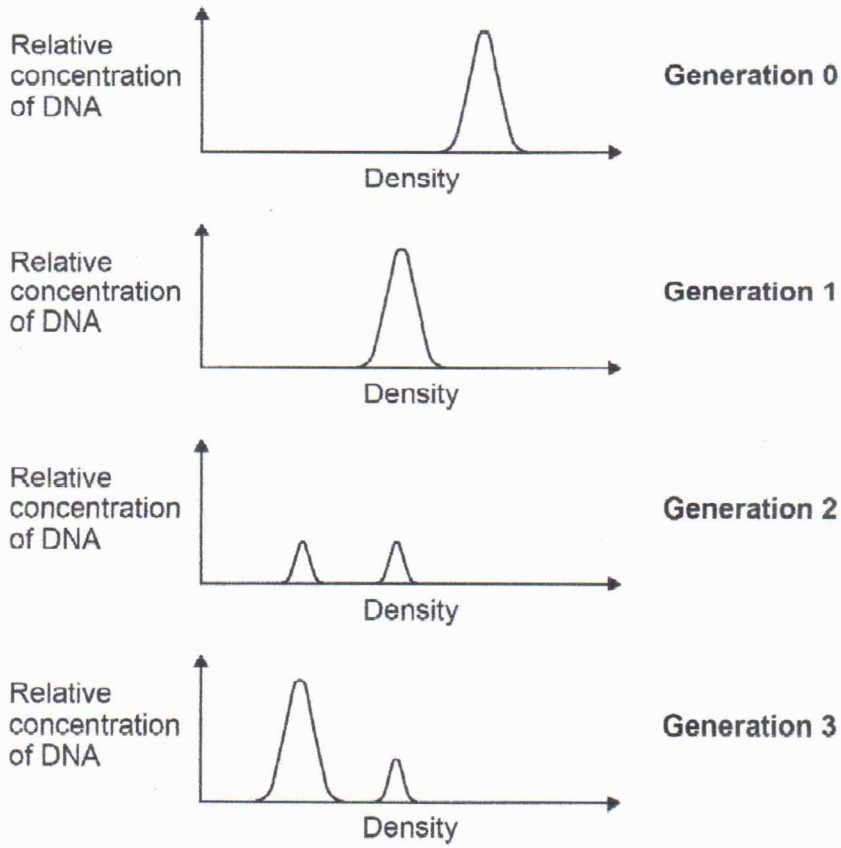
Question 9 continues on the next page

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

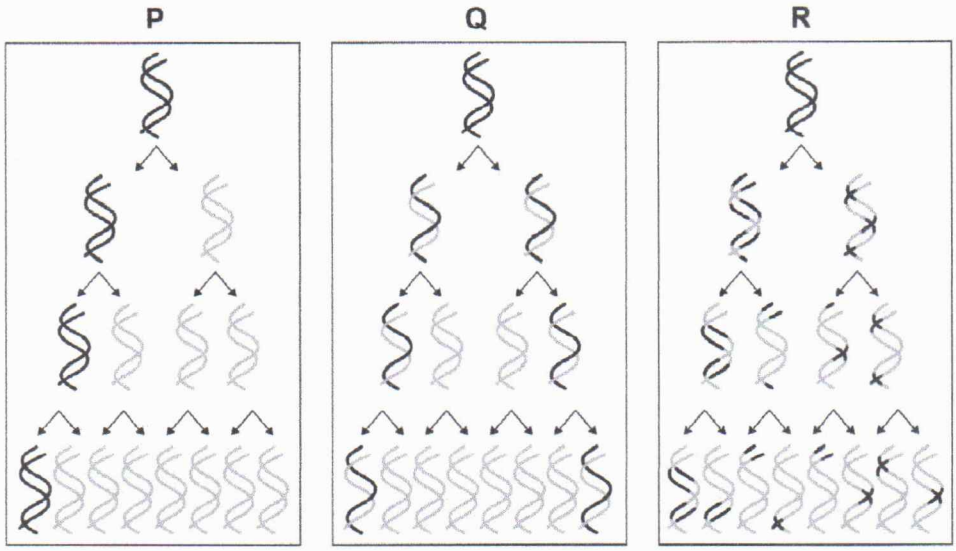


Do not write outside the box

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 unsupported because according to figure 12 there should be 2 peaks P has one.

Explanation for second **unsupported** model R unsupported because there should be two peaks in generation 2 and 3.

7

Turn over ▶

Do not write outside the box

1 0 . 1 Describe the structure of DNA.

[5 marks]

DNA is a polymer of nucleotides. Each nucleotide is made of three components linked together by covalent bonds. These are

(i) a phosphate group

(ii) a deoxyribose sugar

(iii) a nitrogenous base which are four of Adenine, guanine, cytosine and thymine. The nucleotide contains only one of the four bases. The nucleotides are linked by phosphodiester bonds forming a long polynucleotide chain.

The DNA is made of two polynucleotide chains twisted on each other to form a double helix in the two strands nucleotides with adenine always binds with nucleotide contain thymine in the other strand and those with guanine binds with those with cytosine in the other strand. ie Adenine and thymine are complementary and guanine and cytosine are complementary. They are joined together by hydrogen bonds.

Do not write outside the box

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

[5 marks]

(i) Simple diffusion: In simple diffusion materials ie small non-polar molecules moves from a region of high concentration to a region of low concentration across the membrane through the phospholipids

(ii) Facilitated diffusion - materials move from a region of high concentration to a region of low concentration however these one use protein channels because they are large molecules.

(iii) Osmosis: This is movement of water across the membrane from a region of high water potential to a region of low water potential.

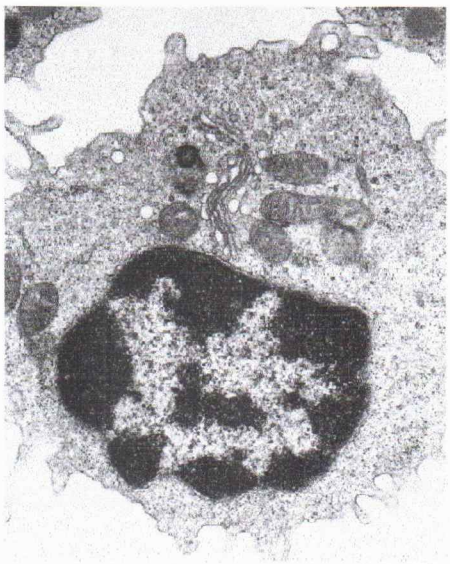
(iv) Active transport: Here molecules are moved against their concentration gradient. This requires energy and therefore ATP is used by protein carriers found on the membrane to move these molecules against their concentration gradient.

Question 10 continues on the next page

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

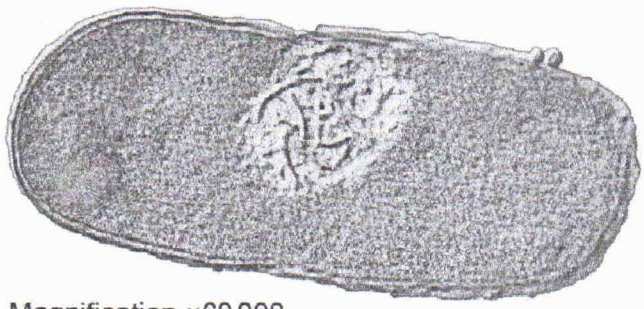
Figure 14

Cell A



Magnification ×30 000

Cell B



Magnification ×60 000

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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]

a) The magnification indicate A is bigger than B. A is magnified 30,000 times while B is magnified 60,000 times.

(2) A is a Eukaryotic cell, they have mitochodria while B does not

(3) A has Golgi bodies and rough endoplasmic reticulum while B does not.

(4) A has nucleus whereas B does not It has a loopy DNA which is not enclosed in a nucleus.

(5) A has large ribosomes (80S) while B has 70S ribosomes which are smaller.

(6) In A DNA is bound to proteins called histones while in cell B DNA is not associated with histones

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END OF QUESTIONS