SPECIMEN MATERIAL

A-level
BIOLOGY
(7402/2)
Paper 2

Specimen 2014 Session Time allowed: 2 hours

Materials
For this paper you must have:
- a ruler with millimetre measurements
- a calculator.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the bottom of this page.
- Answer **all** questions.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 91.

Please write clearly, in block capitals, to allow character computer recognition.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

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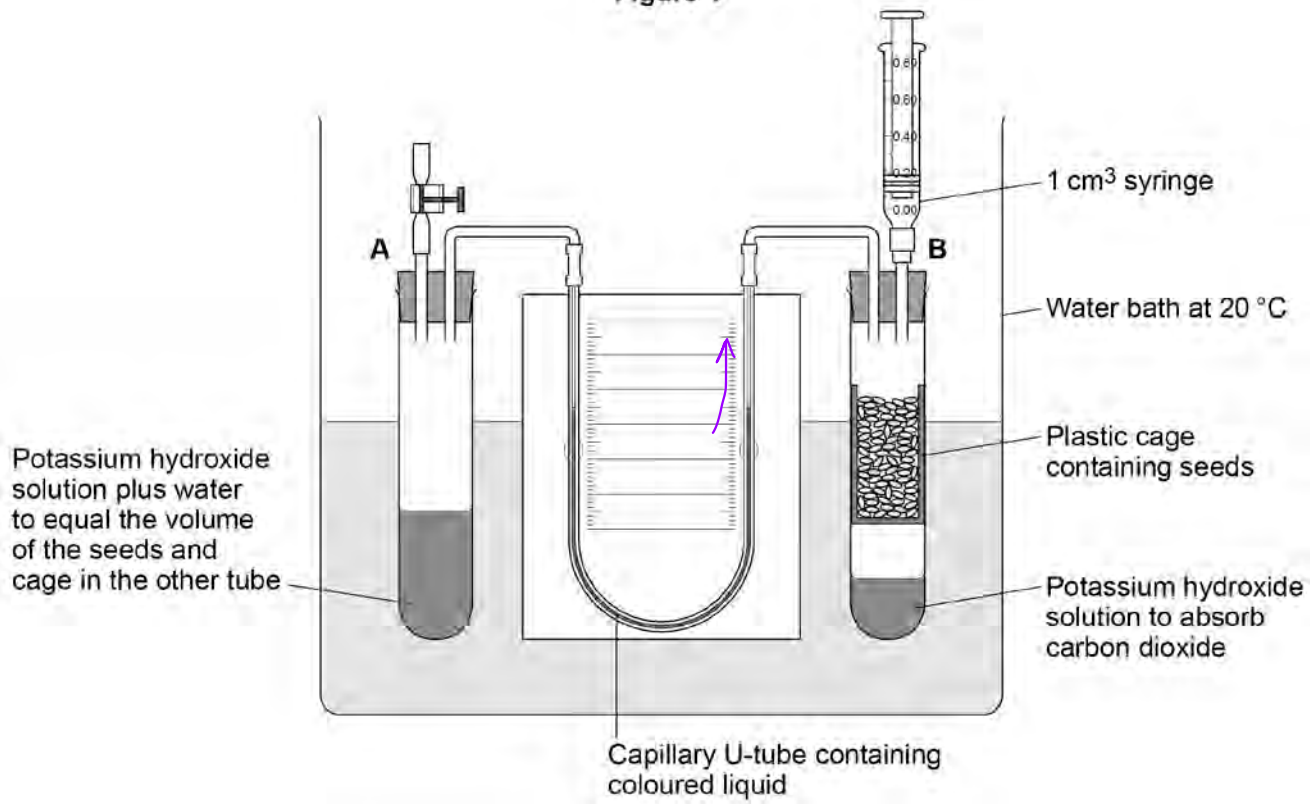
Answer **all** questions in the spaces provided.

1 **Figure 1** shows the apparatus used for measuring the rate of oxygen consumption in aerobic respiration by seeds.

Figure 1



0 1 . 1 For the first 10 minutes, the tap attached to tube **A** was left open and the syringe from tube **B** was removed.

Suggest **three** reasons why the apparatus was left for 10 minutes.

[3 marks]

1 To allow for an equilibrium to be reached.

2 To allow for pressure change within the apparatus.

3 To allow for the respiration rate of the seeds to stabilise.

0 1 . 2 Suggest and explain why the chosen temperature was 20 °C for this experiment.

[2 marks]

this is to replicate the temperature at which normal growth of seeds would occur at, but also provide an optimal temperature for respiratory enzymes to work at.

Question 1 continues on the next page

After 10 minutes, the tap attached to tube **A** was closed and the syringe was attached to tube **B**. Every minute, the syringe plunger was moved until the levels in the U-tube were the same. The reading on the syringe volume scale was then recorded.

The results are shown in **Table 1**.

Table 1

Time / minutes	Reading on syringe volume scale / cm^3
0	0.84
1	0.81
2	0.79
3	0.76
4	0.73
5	0.70
6	0.68
7	0.66
8	0.63
9	0.62
10	0.58

$0.84 - 0.58 = 0.26 cm^3$

60mins = 1hr ÷6 ÷6

10mins = $\frac{1}{6}$ hr

0 1 . 3 During the experiment, the coloured liquid in the tubing moved towards tube **B**. Explain what caused this.

[3 marks]

As the seeds respire throughout the experiment, oxygen is taken up. At the same time CO_2 is given out, however this is absorbed by the potassium hydroxide solution at the bottom of tube B. As a result, the volume in tube B decreases causing the coloured liquid in the tubing to move towards tube B.

[Extra space]

0 1 . 4 The mass of the seeds was 1.6 g. Use the information in **Table 1** to calculate the rate of oxygen consumption in $cm^3\ g^{-1}\ hour^{-1}$ by the seeds.

Show your working.

[2 marks]

$$\text{rate} = \frac{0.26 cm^3}{\frac{1.6\ g}{\frac{1}{6}\ hr}} = 0.975$$

Rate = 0.98 $cm^3\ g^{-1}\ hour^{-1}$

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

0 2 . 1 Describe the roles of calcium ions and ATP in the contraction of a myofibril.

[5 marks]

The calcium ions diffuse into the myofibrils from the sarcoplasmic reticulum. The calcium ions cause the movement of the tropomyosin molecules that were originally blocking the binding sites on the actin filament. This movement exposes the binding sites of the actin. The myosin heads attach to the binding sites on the actin, and change their angle, pulling the actin filament along as they do so. As a result, a molecule of ADP is released. An ATP molecule attaches to each myosin head, and this causes the myosin head to detach from the actin filament. The presence of calcium ions cause the hydrolysis of ATP to ADP, which provides energy for the myosin heads to bend and return to its original position. The myosin head (with an attached ADP molecule) attaches further down the actin filament and the cycle repeats.

[Extra space]

The attachment of an ATP molecule to each myosin head causes myosin heads to detach from the actin site.

0 2 . 2 ATP is an energy source used in many cell processes. Give **two** ways in which ATP is a suitable energy source for cells to use.

[2 marks]

1 ATP releases energy instantaneously

2 ATP releases small amounts of energy when hydrolysed and as a result, little energy is lost as heat.

0 3 . 1 In fruit flies, the genes for body colour and wing length are linked. Explain what this means.

[1 mark]

the genes for body colour and wing length are on the same chromosome.

A scientist investigated linkage between the genes for body colour and wing length. He carried out crosses between fruit flies with grey bodies and long wings and fruit flies with black bodies and short wings.

Figure 2 shows his crosses and the results.

- **G** represents the dominant allele for grey body and **g** represents the recessive allele for black body.
- **N** represents the dominant allele for long wings and **n** represents the recessive allele for short wings.

Figure 2

Phenotype of parents	grey body, long wings	×	black body, short wings
Genotype of parents	**GGNN**		**ggnn**
Genotype of offspring	**GgNn**		
Phenotype of offspring	all grey body, long wings		

These offspring were crossed with flies homozygous for black body and short wings.

The scientist's results are shown in **Figure 3**.

1. GN 2. gn
3. Gn 4. gN

Figure 3

GgNn crossed with **ggnn**

	Grey body, long wings	**Black body, short wings**	**Grey body, short wings**	**Black body, long wings**
Number of offspring	975	963	186	194

Gg nn gg Nn

0 3 . 2 Use your knowledge of gene linkage to explain these results.

[4 marks]

GgNn individuals produce the gametes of GN and gn. In addition, crossing over has produced much fewer gametes of the form Gn and gN. When we cross the gametes that have been produced via crossing over with an individual that has the genotype of ggnn, we find that fewer individuals with the genotype Ggnn and ggNn are produced. Therefore, this proves that GN and gn are linked.

[Extra space]

0 3 . 3 If these genes were **not** linked, what ratio of phenotypes would the scientist have expected to obtain in the offspring?

[1 mark]

1 : 1 : 1 : 1

0 3 . 4 Which statistical test could the scientist use to determine whether his observed results were significantly different from the expected results?

Give the reason for your choice of statistical test.

[2 marks]

Chi-squared test - this is because the data is categorical

4 A biologist investigated the stimulation of a Pacinian corpuscle in the skin of a fingertip.
She used microelectrodes to measure the maximum membrane potential of a Pacinian corpuscle and its sensory neurone when different pressures were applied to the fingertip.

Figure 4 shows the Pacinian corpuscle, its sensory neurone and the position of the microelectrodes.

Figure 4

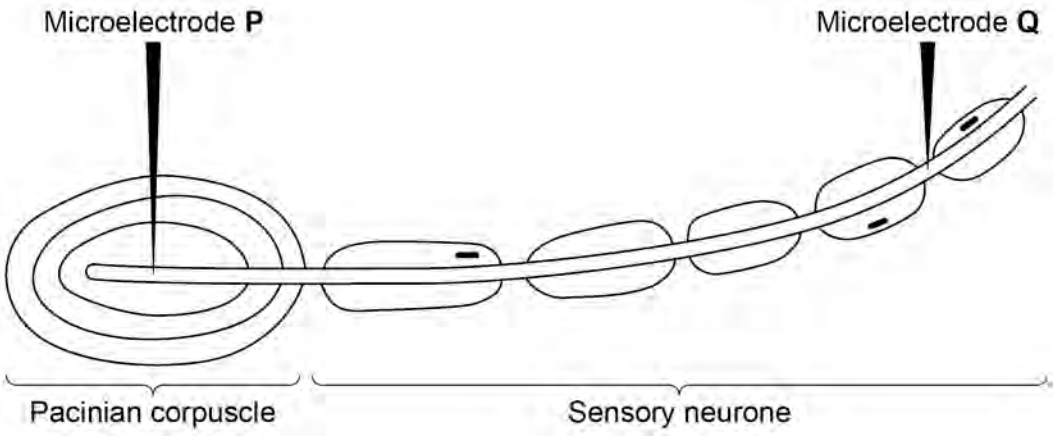


Table 2 shows some of the biologist's results.

Table 2

Pressure applied to the fingertip	Membrane potential at P / millivolts	Membrane potential at Q / millivolts
None	–70	–70
Light	–50	–70
Medium	+30	+40
Heavy	+40	+40

0 4 . 1 Explain how the resting potential of –70 mV is maintained in the sensory neurone when no pressure is applied.

[2 marks]

The axon membrane is more permeable to potassium ions and less permeable to sodium ions ✓. To maintain the concentration and uneven distribution of ions across the membrane, the Na^+ ions are actively transported out of the cell ✓, whilst K^+ ions move in.

0 4 . 2 Explain how applying pressure to the Pacinian corpuscle produces the changes in membrane potential recorded by microelectrode **P**.

[3 marks]

The application of pressure causes the axon membrane to become stretched. This stimulus causes some of the voltage-gated sodium channels in the axon membrane to open. The increase in permeability allows for the Na^+ ions to rapidly diffuse into the axon, down the concentration gradient. With an increase in pressure exerted, the permeability of the axon membrane increases, allowing for more sodium ions to enter.

[Extra space]

0 4 . 3 The membrane potential at **Q** was the same whether medium or heavy pressure was applied to the finger tip. Explain why.

[2 marks]

The certain threshold value had been reached and caused a maximal response.

0 4 . 4 Multiple sclerosis is a disease in which parts of the myelin sheaths surrounding neurones are destroyed. Explain how this results in slower responses to stimuli.

[2 marks]

No saltatory conduction will occur and as a result, there will be more depolarisation over the length of the membrane.

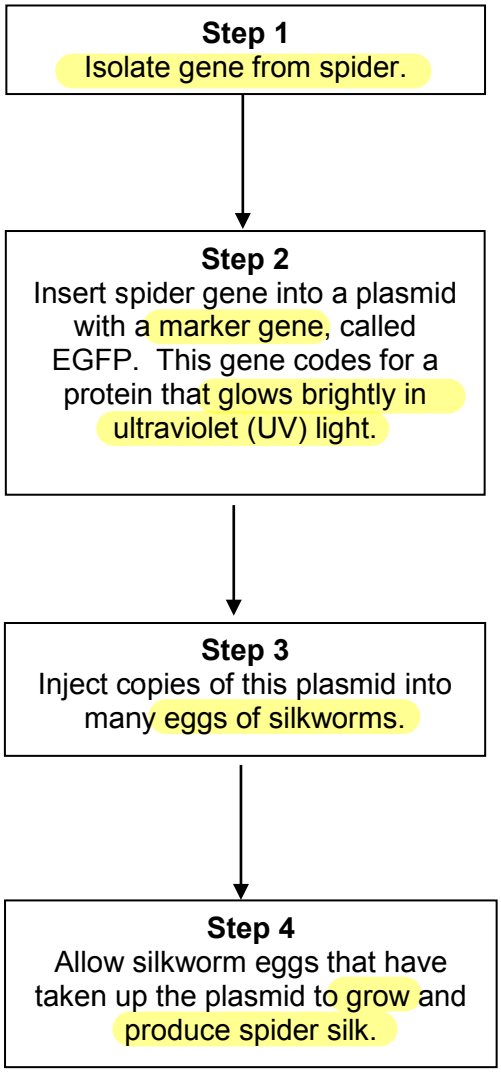
5 Silkworms secrete silk fibres, which are harvested and used to manufacture silk fabric.

Scientists have produced genetically modified (GM) silkworms that contain a gene from a spider.

The GM silkworms secrete fibres made of spider web protein (spider silk), which is stronger than normal silk fibre protein.

The method the scientists used is shown in **Figure 5**.

Figure 5



0 5 . 1 Suggest why the plasmids were injected into the eggs of silkworms, rather than into the silkworms.

[2 marks]

If the gene is injected into the egg of the silkworms, most of the cells of the silkworm will contain the gene and so the gene will get into the cells that make the silk.

0 5 . 2 Suggest why the scientists used a marker gene and why they used the EGFP gene.

[2 marks]

Not all the eggs will have successfully taken up the plasmid, but the marker gene indicates which of the silkworms have successfully taken up the spider gene by glowing under UV light.

The scientists ensured the spider gene was expressed only in cells within the silk glands.

0 5 . 3 What would the scientists have inserted into the plasmid along with the spider gene to ensure that the spider gene was only expressed in the silk glands of the silkworms?

[1 mark]

promoter gene

0 5 . 4 Suggest **two** reasons why it was important that the spider gene was expressed only in the silk glands of the silkworms.

[2 marks]

1 so that the protein can be harvested.

2 Fibres produced in other cells may cause harm

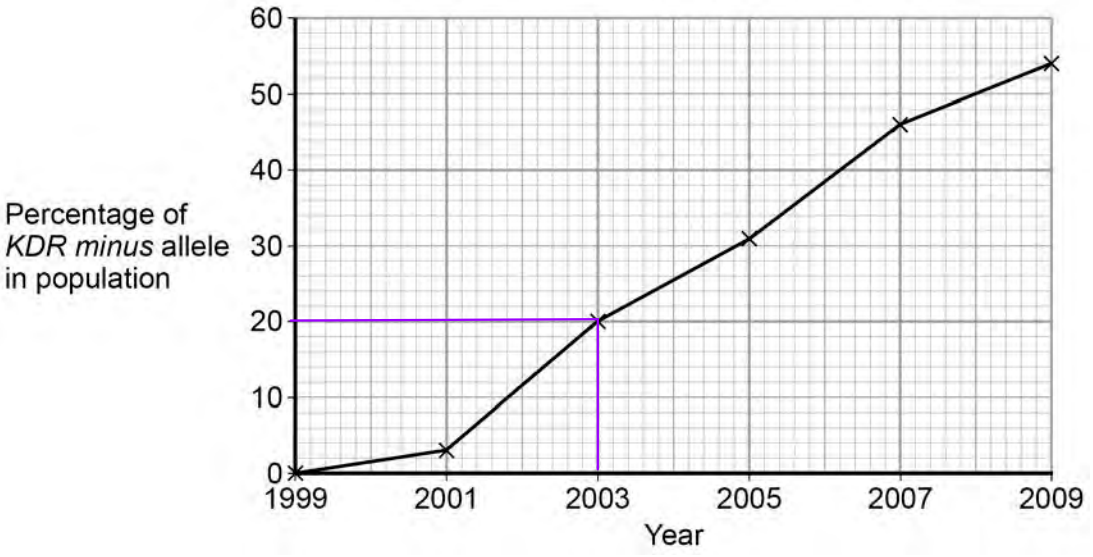
6 Malaria is a disease that is spread by insects called mosquitoes. In Africa, DDT is a pesticide used to kill mosquitoes, to try to control the spread of malaria.

Mosquitoes have a gene called *KDR*. Today, some mosquitoes have an allele of this gene, *KDR minus*, that gives them resistance to DDT. The other allele, *KDR plus*, does not give resistance.

Scientists investigated the frequency of the *KDR minus* allele in a population of mosquitoes in an African country over a period of 10 years.

Figure 6 shows the scientists' results.

Figure 6



0 6 . 1 Use the Hardy–Weinberg equation to calculate the frequency of mosquitoes heterozygous for the *KDR* gene in this population in 2003.

Show your working.

[2 marks]

Hardy-Weinburg equations:

$p + q = 1$

$p^2 + 2pq + q^2 = 1$

KDR minus allele freq. = 0·2

KDR plus allele freq. = 0·8

$2 \times (0{\cdot}2) \times (0{\cdot}8)$

$= 0{\cdot}32$

Frequency of heterozygotes in population in 2003 0·32

0 6 . 2 Suggest an explanation for the results in **Figure 6.**

[4 marks]

A mutation has produced the KDR minus resistance allele. The DDT pesticide used to kill the mosquitoes has provided a selection pressure. The KDR minus allele is advantageous in this particular environment, and so the mosquitoes that contain the KDR minus allele are more likely to survive and reproduce. Therefore over time, we see a steady increase in the KDR minus allele percentage in this population.

[Extra space]

The *KDR plus* allele codes for the sodium ion channels found in neurones.

0 6 . 3 When DDT binds to a sodium ion channel, the channel remains open all the time. Use this information to suggest how DDT kills insects.

[2 marks]

The neurones will remain depolarised all the time, so there will be no neurone transmission.

0 6 . 4 Suggest how the *KDR minus* allele gives resistance to DDT.

[2 marks]

This is possible through a mutation that causes a change in shape of the sodium ion channel protein, and as a result, the DDT is no longer complementary to the receptor on the protein.

7 Osmoreceptors are specialised cells that respond to changes in the water potential of the blood.

0 7 . 1 Give the location of osmoreceptors in the body of a mammal.

[1 mark]

hypothalamus

0 7 . 2 When a person is dehydrated, the cell volume of an osmoreceptor decreases. Explain why.

[2 marks]

As the person is dehydrated, the lack of fluid intake has decreased the water potential of the blood. As a result, by osmosis, water moves from the osmoreceptor into the blood.

0 7 . 3 Stimulation of osmoreceptors can lead to secretion of the hormone ADH. Describe and explain how the secretion of ADH affects urine produced by the kidneys.

[4 marks]

Increasing the secretion of ADH, increases the permeability of the distil convulated tubule and collecting duct walls to water. As a result, more water is reabsorbed from the medulla into the blood in the vasa recta. As the water potential of the blood is restored to normal, a small volume of urine is produced that is more concentrated than usual.

[Extra space]

The efficiency with which the kidneys filter the blood can be measured by the rate at which they remove a substance called creatinine from the blood. The rate at which they filter the blood is called the glomerular filtration rate (GFR).

In 24 hours, a person excreted 1660 mg of creatinine in his urine. The concentration of creatinine in the blood entering his kidneys was constant at 0.01 mg cm^{-3}.

0 7 . 4 Calculate the GFR in cm^3 $minute^{-1}$.

[1 mark]

24 hours = 1440 minutes

$\frac{1660\ mg}{1440\ min.} = 1.1527\ mg/min.$

$\frac{1.1527}{0.01} = 115.27\ cm^3\ minute^{-1}$

Answer = 115.3

0 7 . 5 Creatinine is a breakdown product of creatine found in muscle tissues. Apart from age and gender, give **two** factors that could affect the concentration of creatinine in the blood.

[1 mark]

1 ethnicity

2 the amount of exercise a person takes part in

- muscle mass
- kidney disease

Turn over for the next question

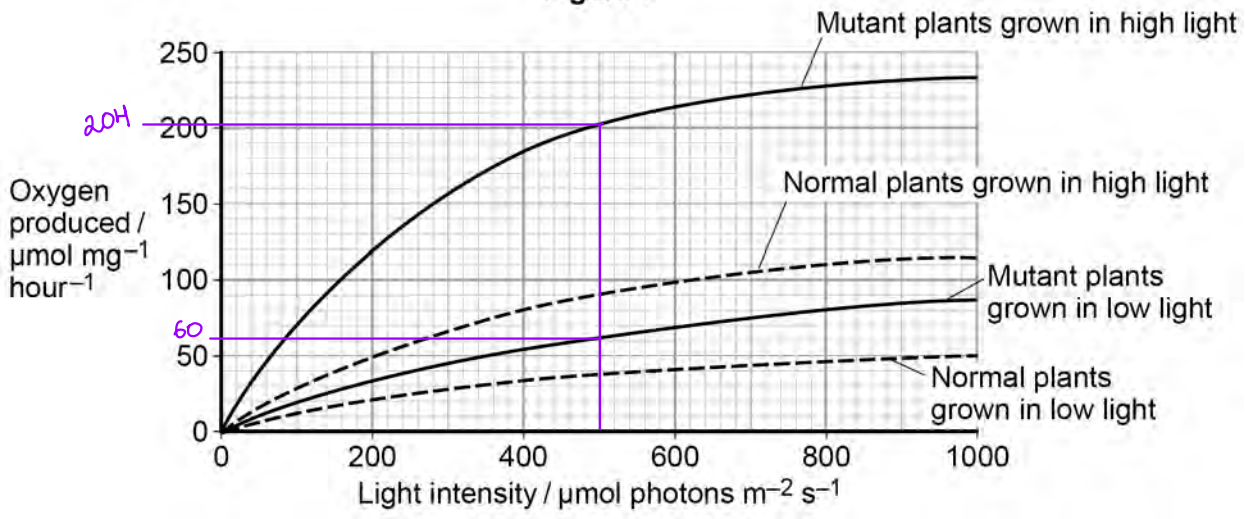
8 Chloroplasts contain chlorophyll a and chlorophyll b. Scientists found tobacco plants with a mutation that caused them to make more chlorophyll b than normal tobacco plants. They investigated the effect of this mutation on the rate of photosynthesis.

The scientists carried out the following investigation.

- They grew normal and mutant tobacco plants. They grew some of each in low light intensity and grew others in high light intensity.
- They isolated samples of chloroplasts from mature plants of both types.
- Finally, they measured oxygen production by the chloroplasts they had isolated from the plants.

Figure 7 shows the scientists' results.

Figure 7



0 8 . 1 Explain why the scientists measured the rate of production of oxygen in this investigation.

[2 marks]

Oxygen is produced in the light dependent reaction, and so the faster the rate of production of oxygen, the faster the light dependent reaction.

In each trial, the scientists collected oxygen for 15 minutes.

0 8 . 2 Calculate the difference in the oxygen produced by the chloroplasts from mutant plants grown in low and high light intensities at a light intensity of 500 µmol photons m^{-2} s^{-1}.

Show your working.

[2 marks]

204 - 60

= 144 µmol mg^{-1} $hour^{-1}$

$\frac{144}{4}$ = 36 µmol O_2 mg^{-1} $hour^{-1}$

Difference 36 µmol O_2 mg^{-1} $hour^{-1}$

0 8 . 3 The scientists suggested that mutant plants producing more chlorophyll b would grow faster than normal plants in all light intensities.

Explain how these data support this suggestion.

[4 marks]

At all light intensities, chloroplasts from mutant plants have had a higher production of oxygen. They have also had faster production of ATP and reduced NADP. As a result, the light independent reaction in the mutant plants have been faster, and so they produce more sugars that can be used in respiration. Therefore they have more energy for growth and are able to synthesise new organic materials faster.

[Extra space]

0 9 . 1 Explain how the methylation of tumour suppressor genes can lead to cancer.

[3 marks]

The process of methylation prevents the transcription of a gene. As a result, the protein that is usually produced and functions in apoptosis is no longer transcribed and translated, and so the tumour suppressor gene has been inactivated. Now, there is no control over mitosis, and so uncontrolled cell division occurs.

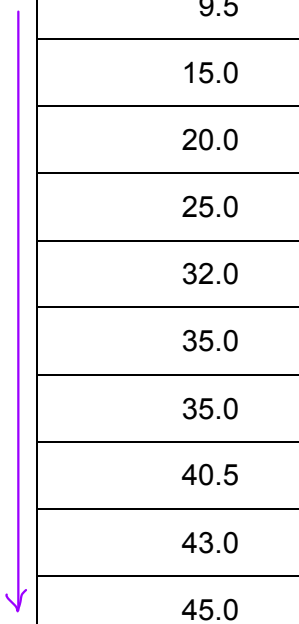
[Extra space]

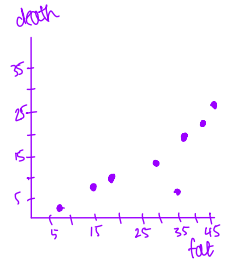
Scientists investigated a possible relationship between the percentage of fat in the diet and the death rate from breast cancer in women from 10 countries.

Their data is shown in **Table 3**.

Table 3

Percentage of fat in diet of population	Death rate of women from breast cancer per 100 000 women
9.5	1.5
15.0	7.0
20.0	12.0
25.0	9.0
32.0	15.0
35.0	8.0
35.0	20.0
40.5	18.0
43.0	24.0
45.0	26.0





0 9 . 2 Describe how you would plot a suitable graph of these data. Explain your choice of type of graph.

[3 marks]

Scatter graph - percentage of fat on x-axis and death rate on y-axis. The relationship between the two variables is that the percentage of fat in the diet has likely affected and impacted the death rate from breast cancer in women. Therefore the percentage of fat in the diet is placed on the x-axis, and the death rate on the y-axis.

[Extra space]

0 9 . 3 What can you conclude from these data?

[2 marks]

there is a positive correlation trend between fat in diet and death rate for breast cancer. So this data shows that more fat in diet leads to a higher death rate from breast cancer. Although there are a number of anomalies, the positive relationship is still clear.

Turn over for the next question

1 0 Read the following passage carefully.

A large and growing number of disorders are now known to be due to types of mitochondrial disease (MD). MD often affects skeletal muscles, causing muscle weakness.

We get our mitochondria from our mothers, via the fertilised egg cell. Fathers do not pass on mitochondria via their sperm. Some mitochondrial diseases are caused by mutations of mitochondrial genes inside the mitochondria. Most mitochondrial diseases are caused by mutations of genes in the cell nucleus that are involved in the functioning of mitochondria. These mutations of nuclear DNA produce recessive alleles.

One form of mitochondrial disease is caused by a mutation of a mitochondrial gene that codes for a tRNA. The mutation involves substitution of guanine for adenine in the DNA base sequence. This changes the anticodon on the tRNA. This results in the formation of a non-functional protein in the mitochondrion.

There are a number of ways to try to diagnose whether someone has a mitochondrial disease. One test involves measuring the concentration of lactate in a person's blood after exercise. In someone with MD, the concentration is usually much higher than normal. If the lactate test suggests MD, a small amount of DNA can be extracted from mitochondria and DNA sequencing used to try to find a mutation.

Use information in the passage and your own knowledge to answer the following questions.

1 0 . 1 Mitochondrial disease (MD) often causes muscle weakness (lines 1–3). Use your knowledge of respiration and muscle contraction to suggest explanations for this effect of MD.

[3 marks]

A reduction in the production of ATP via aerobic respiration ✓ causes an individual to be unable to respire for long periods of time. Resorting to anaerobic respiration may result in a build-up of lactic acid causing fatigue ✓ and damage to the muscle cells. This eventually leads to muscle weakness. Within the muscle cells, there are fewer interactions between the actin molecules and myosin heads ✓, so less force is generated.

[Extra space]

Two couples, couple **A** and couple **B**, had one or more children affected by a mitochondrial disease. The type of mitochondrial disease was different for each couple.
None of the parents showed signs or symptoms of MD.

- Couple **A** had four children who were all affected by an MD.
- Couple **B** had four children and only one was affected by an MD.

1 0 . 2 Use the information in lines 5–9 and your knowledge of inheritance to suggest why:

- all of couple **A**'s children had an MD
- only one of couple **B**'s children had an MD.

[4 marks]

Couple **A** A probable mutation in the mitochondrial DNA during the formation of the mothers ovary, lead to all the children receiving affected mitochondria from the mother.

Couple **B** A mutation must have occured in the DNA of the nucleus affected. The parents must have therefore been heterozygous in order to produce an offspring with a homozygous recessive genotype.

[Extra space] therefore, we expect 1 in 4 of the homozygous offspring to be affected.

Question 10 continues on the next page

1 0 . 3 Suggest how the change in the anticodon of a tRNA leads to MD (lines 10–13).

[3 marks]

A change to the tRNA molecules lead to wrong amino acids being incorporated into the protein. As a result, the tertiary structure of the protein will change, and the protein required for the Krebs cycle is no longer produced. Respiration is no longer efficient, and so less ATP is produced.

[Extra space]

1 0 . 4 If someone has MD, the concentration of lactate in their blood after exercise is usually much higher than normal (lines 15–17). Suggest why.

[3 marks]

An individual with MD will have mitochondria that are unable to produce as much ATP as usual. As a result, this demand is supplied through an increase in anaerobic respiration. More lactate is produced and so the concentration of lactate in their blood after exercise increases. The lactate eventually leaves the muscle via facilitated diffusion.

[Extra space]

1 0 . 5 A small amount of DNA can be extracted from mitochondria and DNA sequencing used to try to find a mutation (lines 18–19).

From this sample:

- how would enough DNA be obtained for sequencing?
- how would sequencing allow the identification of a mutation?

[2 marks]

sufficient DNA can be obtained through PCR secondly, to identify a mutation in the sequence, we need to compare the DNA sequence to a 'normal' DNA.

END OF QUESTIONS

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