



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 2

Thursday 11 June 2020

Morning

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	
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9	
10	
TOTAL	



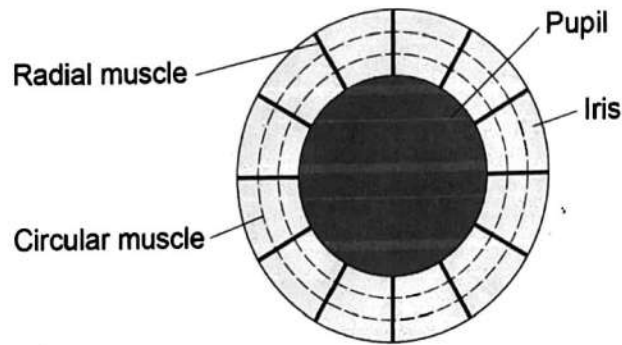
Answer all questions in the spaces provided.

0 1

The iris in the human eye is a muscular structure. The iris changes the size of the pupil.

Figure 1 shows the muscles in the iris.

Figure 1



0 1 . 1

Suggest and explain how the interaction between the muscles labelled in Figure 1 could cause the pupil to constrict (narrow).

[2 marks]

Circular muscles will contract pulling the pupil inwards. Radial muscle relax.



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- 0 1 . 2 The fovea of the eye of an eagle has a high density of cones. An eagle focuses the image of its prey onto the fovea.

Explain how the fovea enables an eagle to see its prey in detail.

Do not refer to colour vision in your answer.

[3 marks]

Very little retinal convergence, so very high acuity. Cones are connected to separate, individual neurones, so signal from each can be detected separately, as separate impulses sent to the brain.

Can be distinguished between 2 different cones being stimulated.

- 0 1 . 3 The retina of the human eye has an area of approximately $1.094 \times 10^3 \text{ mm}^2$

The circular fovea in a human eye has a diameter of $3 \times 10^3 \mu\text{m}$

Calculate the area of the fovea as a percentage of the area of the retina.

The area of a circle is πr^2 . Use $\pi = 3.14$ in your calculation.

Show your working.

$$3000 \mu\text{m} = 3 \text{ mm} \Rightarrow 1.5 = r$$

[2 marks]

$$\frac{(1.5)^2 \times 3.14}{1.094 \times 10^3} = 6.4579 \times 10^{-3}$$

$$6.4579 \times 10^{-3} \times 100 \Rightarrow \underline{0.6457\%}$$

$$\underline{0.6\%}$$

Answer 0.6 %

Question 1 continues on the next page

Turn over ►



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0 1 . 4

The retina of an owl has a high density of rod cells.

Explain how this enables an owl to hunt its prey at night.

Do not refer to rhodopsin in your answer.

[3 marks]

High visual sensitivity, so light reflected even at low intensity can be picked up. Many rods are connected to a single neurone, so stimulation of only a single rod receptor will generate rods at only low intensity will combined produce enough stimulation to neurone to overcome the threshold to produce nerve impulse.



0 2

Testosterone is a steroid hormone that belongs to a group of male sex hormones called androgens.

0 2 . 1

Steroid hormones are hydrophobic.

Explain why steroid hormones can rapidly enter a cell by passing through its cell-surface membrane.

[2 marks]

Hydrophobic so lipid soluble, so can easily diffuse across the phospholipid bilayer

0 2 . 2

In the cytoplasm, testosterone binds to a specific androgen receptor (AR). An AR is a protein.

Suggest and explain why testosterone binds to a specific AR.

[2 marks]

Receptor has a specific shape complementary to the testosterone's shape. This is due to highly specific tertiary structure and folding of proteins

Question 2 continues on the next page

Turn over ►



0 2 . 3

The binding of testosterone to an AR changes the shape of the AR. This AR molecule now enters the nucleus and stimulates gene expression.

Suggest how the AR could stimulate gene expression.

[2 marks]

It can be a promoter protein that stimulates / helps the binding of RNA polymerase to the DNA.

The gene that codes for the AR has a variable number of CAG repeats. Some studies have shown an association between the number of CAG repeats and the risk of developing prostate cancer.

Table 1 shows the results of a statistical test from one study.

Table 1

Number of CAG repeats in the AR gene	Probability (P) value
< 16	0.02
< 17	0.30
< 18	0.07
< 19	0.09
> 20	0.06

0 2 . 4

What can you conclude from the data in Table 1?

[3 marks]

With 16 or fewer there is a significant relationship. While with 17 or more there is no significant relationship / association.

With 16 or less there is a less than 5% chance of the results being due to chance, so we can reject the null hypothesis. While for 17 or above we can't so must accept the null hypothesis.

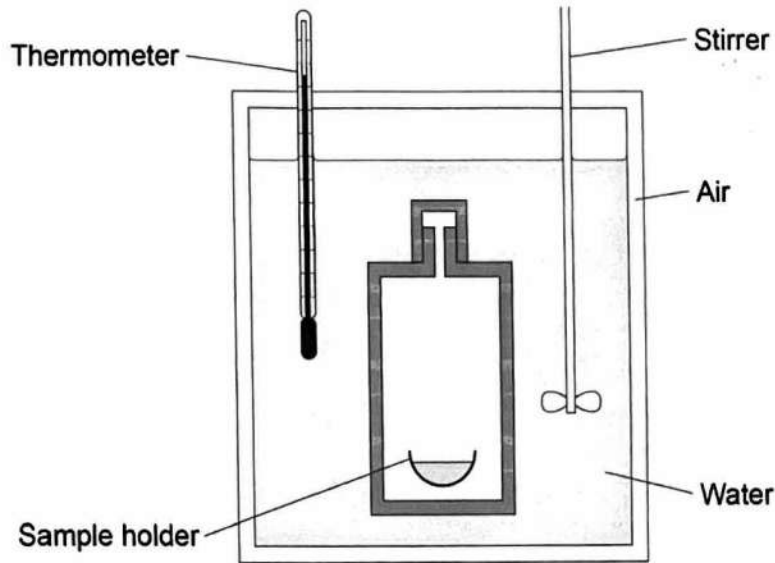


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0 3

Figure 2 shows one type of calorimeter.

Figure 2



A calorimeter can be used to determine the chemical energy store of biomass. A known mass of biomass is fully combusted in a calorimeter. The heat energy released from this combustion increases the temperature of the water in the calorimeter. The increase in the temperature of a known volume of water is recorded.

0 3 . 1

Other than the thermometer, explain how **two** features of the calorimeter shown in Figure 2 would enable a valid measurement of the total heat energy released.

[2 marks]

1 Insulation minimises heat loss to surrounding.

2 Stirrer distributes heat evenly in the ~~test~~ water.

Question 3 continues on the next page

Turn over ►



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0 3 . 2

A 2 g sample of biomass was fully combusted in a calorimeter.

The volume of water in the calorimeter was 100 cm³

The increase in temperature recorded was 15.7 °C

4.18 J of energy are needed to increase the temperature of 1 cm³ of water by 1 °C

Use this information to calculate the heat energy released in kJ per g of biomass.

Show your working.

$$2g \rightarrow 15.7^{\circ}C \text{ of } 100cm^3$$

[2 marks]

$$4.18 J / 1cm^3 / 1^{\circ}C$$

$$4.18 \times 15.7 \times 100 = 6562.6 - \text{for } 2g$$

$$\text{for } 1g = \frac{6562.6}{2} = 3281.8 J/g$$

$$\rightarrow 3.2818 kJ/g$$

Answer 3.28 kJg⁻¹

Plants and algae produce fuels called biofuels. Scientists have used *Chlorella* to produce biofuel. *Chlorella* is a genus of single-celled photosynthetic alga. *Chlorella* can be grown in open ponds and fermenters.

0 3 . 3

In natural ecosystems, most of the light falling on producers is **not** used in photosynthesis.

Suggest **two** reasons why.

[2 marks]

1 Reflection from the leaf surface

2 Other factor like CO₂ concentration or temperature are the limiting factor of photosynthesis's.



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0 3 . 4 The light absorbed by chlorophyll is used in the light-dependent reaction.

Name the **two** products of the light-dependent reaction that are required for the light-independent reaction.

[2 marks]

1 Reduced NADP

2 ATP

0 3 . 5 *Chlorella* cells can divide rapidly. A culture of 2000 *Chlorella* cells was set up in a fermenter. The cells divided every 90 minutes.

You can assume that there were no limiting factors and that no cells died during the 24 hours.

Calculate the number of cells in the culture after 24 hours.

Give your answer in standard form.

Show your working.

$$1.5 \text{ h} = 2000 \times 2$$

[2 marks]

$$\frac{24}{1.5} = 16$$

$$2000 \times 2^{16} = 131072000$$

$$\underline{1.3 \times 10^8}$$

Answer 1.3 × 10⁸

10

Turn over for the next question

Turn over ►

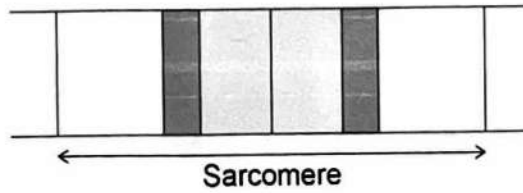


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0 4

Figure 3 shows the banding pattern of a single sarcomere.

Figure 3



0 4 . 1

Explain the banding pattern shown in Figure 3.

[3 marks]

light band is the band I made from only actin.

light grey is zone H made up from only myosin

Darkest band is where actin and myosin overlap.



Creatinine is produced in muscle tissues. Creatinine diffuses into the blood. The kidneys then excrete creatinine.

A calibration curve can be used to determine the concentration of creatinine in urine. One method of producing a calibration curve needs:

- creatinine solution of known concentration
- distilled water
- creatinine-detecting solution
- a colorimeter.

Creatinine-detecting solution reacts with creatinine to produce an orange colour.

0 4 . 2

Use the information provided to describe how you could produce a calibration curve for creatinine.

Do **not** include details on the use of glassware in your answer.

[4 marks]

Produce a serial dilution on creatinine solution, with distilled water.

Add ~~creat~~ creatinine detecting solution to each dilution. Making sure each solution has the same volume only their concentration varies.

Adding the same amount of creatinine detecting solution to each.

Use a colorimeter to measure the absorbance of each sample solution.

Plot dilution concentration against absorbance to create graph. Connecting points with smooth curve for calibration curve.

Turn over ►



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0 4 . 3

Describe how you would determine the concentration of creatinine in a urine sample using your calibration curve.

[2 marks]

Add same volume of creatinine detecting solution as used for the curve, to the same volume of urine sample as each sample was. Measure absorbance and read off from graph the value falling for concentration at the given absorbance.

9



0 5

Describe the sequence of events involved in transmission across a cholinergic synapse.

Do not include details on the breakdown of acetylcholine in your answer.

[5 marks]

The nerve impulse reaches the synapse of 1st neurone, depolarising the presynaptic membrane.

As calcium ions enter by calcium channels opening on the synaptic knob.

The Ca^{2+} ions cause synaptic vesicles to move towards and fuse with the presynaptic membrane, releasing acetylcholine (neurotransmitter).

These released acetylcholine molecules diffuse across the synaptic cleft.

Receptors on the postsynaptic membrane bind to the acetylcholine molecules causing Na^{+} (sodium) ions to enter postsynaptic neurone. This leads to depolarisation and therefore the generation of a new nerve impulse.

5

Turn over ►



0 6 . 1 Mutation is one cause of genetic variation in organisms.

Give **two** other causes of genetic variation.

[2 marks]

1 Random fertilisation

2 Crossing over

In a species of flowering plant, the T allele for tallness is dominant to the t allele for dwarfness. In the same species, two alleles C^R (red) and C^W (white) code for the colour of flowers. When homozygous red-flowered plants were crossed with homozygous white-flowered plants, all the offspring had pink flowers.

0 6 . 2 Name the relationship between the two alleles that code for flower colour.

[1 mark]

Co-dominance



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0 6 . 3

A dwarf, pink-flowered plant was crossed with a heterozygous tall, white-flowered plant.

Complete the genetic diagram to show all the possible genotypes and the ratio of phenotypes expected in the offspring of this cross.

[3 marks]

Phenotypes of parents: Dwarf, pink-flowered × Tall, white-flowered

Genotypes of parents: $tt C^R C^W$ $Tt C^W C^W$

X	$t C^R$	$t C^W$	$T C^R$	$T C^W$	$tt C^R C^W = 4$
$T C^W$	$Tt C^R C^W$	$Tt C^W C^W$	$Tt C^R C^W$	$Tt C^W C^W$	$tt C^W C^W = 4$
$T C^W$	$Tt C^R C^W$	$Tt C^W C^W$	$Tt C^R C^W$	$Tt C^W C^W$	$Tt C^R C^W = 4$
$t C^W$	$t C^R C^W$	$t C^W C^W$	$t C^R C^W$	$t C^W C^W$	$Tt C^W C^W = 4$
$t C^W$	$t C^R C^W$	$t C^W C^W$	$t C^R C^W$	$t C^W C^W$	

Genotypes of offspring: $tt C^R C^W, tt C^W C^W, Tt C^R C^W, Tt C^W C^W$

Phenotypes of offspring: dwarf pink, dwarf white, tall pink, tall white

Ratio of phenotypes: 1:1:1:1

0 6 . 4

A population of this species of plant contained 9% of red-flowered plants.

Use the Hardy-Weinberg equation to calculate the percentage of pink-flowered plants in this population.

Show your working.

$$0.09 = p^2$$

$$\Rightarrow p = 0.31$$

$$q = 0.7$$

[2 marks]

$$1 - 0.09 - 0.49 = 2pq$$

$$2pq = 0.42$$

$$\Rightarrow 42\%$$

Answer 42 %

8

Turn over ►



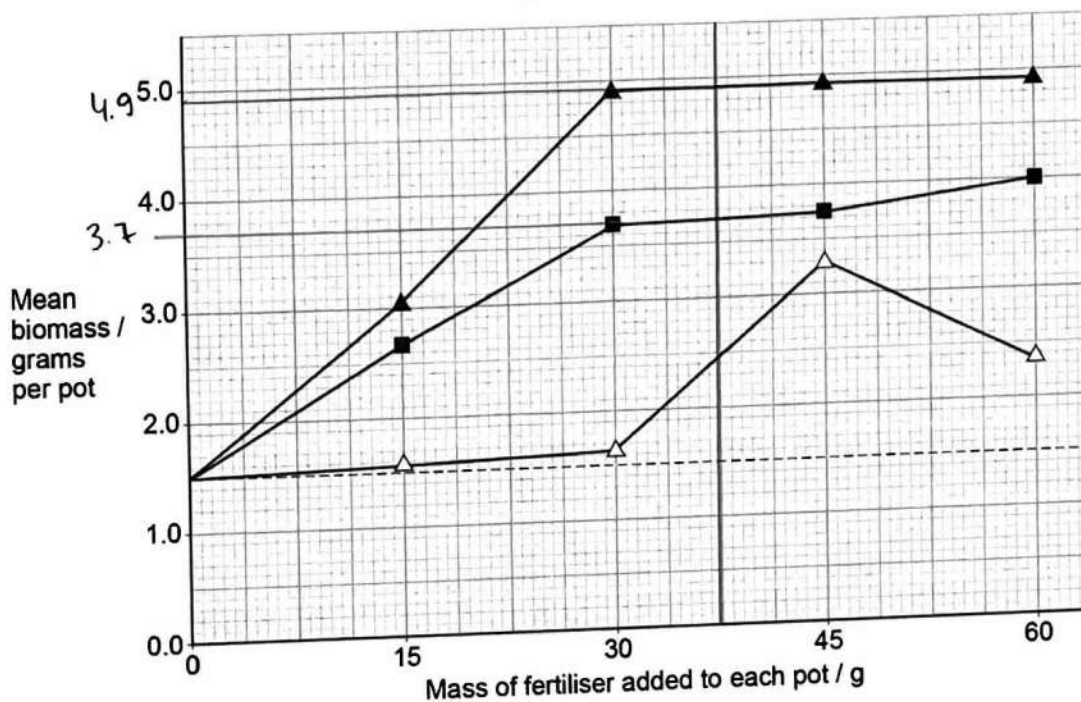
07

A scientist investigated the effects of different fertilisers on the growth of spinach plants. The scientist:

- set up a large sample of identical pots of soil
- added different masses of different fertilisers to selected pots
- did not add fertiliser to the control pots
- planted the same number of young spinach plants in each pot
- after 20 days, determined the biomass of spinach plants in each pot.

The results the scientist obtained after 20 days are shown in Figure 4.

Figure 4



Key

- ▲ Potassium nitrate
- Ammonium sulfate
- △ Chicken manure
- Control – no fertiliser added

07.1

Calculate how many times greater the mean growth rate per day was using 37.5 g potassium nitrate than using 37.5 g ammonium sulfate.

Assume the mean biomass of the spinach plants at the start of the investigation was 0.5 g per pot.

$$\text{Potassium} = 4.9 - 0.5 = 4.4 \text{ g}$$

$$\text{Ammonium} = 3.7 - 0.5 = 3.2 \text{ g}$$

[1 mark]

$$\frac{4.4}{3.2} = 1.375$$

Answer 1.38



07.2

Using all the information, evaluate the effect on plant growth of adding the different fertilisers to the soil.

[5 marks]

Potassium nitrate is most effective, while chicken manure is the least effective.

All are more effective than plants in control group.

No further advantage of potassium nitrate above 30g.

Chicken manure effectiveness decreases above 45g.

However, no statistical test was performed so can't know if differences are significant.

The investigation is only done on spinach, might have different outcome for different plants.

07.3

The scientist determined the dry mass of the spinach plants. First, he heated each sample at 80 °C for 2 hours.

Suggest what the scientist should do to ensure that he has removed all the water from the sample.

[2 marks]

Weigh sample and then heat some more, then weigh again. Repeat till no further change to mass.



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0 8

Alport syndrome (AS) is an inherited disorder that affects kidney glomeruli of both men and women. Affected individuals have proteinuria (high quantities of protein in their urine).

0 8 . 1

Suggest how AS could cause proteinuria.

[2 marks]

Damages the proteins in basement membrane
so that proteins are able to pass into tubule
hence get into urine at high concentrations.

0 8 . 2

AS results from a sex-linked mutation.

In a male with AS, where would the sex-linked mutation be located?

Tick (✓) **one** box.

[1 mark]

The homologous section of a Y chromosome

The homologous section of an X chromosome

The non-homologous section of a Y chromosome

The non-homologous section of an X chromosome



Scientists investigated the use of transplanted stem cells to treat AS in mice.

The scientists set up four experimental groups.

Group A – 40 wild type* mice

Group B – 40 AS mice

Group C – 40 AS mice that received stem cells from AS mice

Group D – 40 AS mice that received stem cells from wild type mice

*Wild type mice are mice **not** affected by AS.

After 20 weeks, the scientists measured the quantity of protein in the urine using a scale from 0 (lowest quantity) to +++++ (highest quantity).

The results the scientists obtained are shown in Table 2.

Table 2

Group	Maximum quantity of protein in urine at 20 weeks	Percentage of mice with this quantity of protein
A	0	100
B	+++++	97.5
C	+++++	100
D	++	68

0 8 . 3 Using all the information, evaluate the use of stem cells to treat AS in humans.

[4 marks]

Treatment D does have lower amount of protein than other treatments so it could be effective, but not fully effective as wild type still has less protein. Reduces protein but not to the level of wild type.

We don't know about rest of the mice in group D outside of the 68%, some could be cured.

Also can't quantitatively compare protein as we don't know exact quantity.

Longer term effects beyond 20 weeks may arise, which could be risky for humans.

Answer space for this question continues on the next page

Turn over ►



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0 8 . 4

The scientists carried out further work to investigate how the transplanted stem cells developed after transplantation.

- The scientists transplanted stem cells from wild type male mice into AS female mice.
- After 20 weeks, they found that the quantity of protein in the urine of these female mice had significantly decreased.
- They examined cells from glomeruli in the female mice. Some of these cells contained a Y chromosome.

Suggest how the transplanted stem cells reduce proteinuria.

[2 marks]

The stem cells specialise / differentiate into cells lining the tubule but without damaged channels. So they reduce the loss of protein at the glomerous.

9



0 9

A scientist produced transgenic zebrafish.

She obtained a gene from silverside fish. The gene codes for a growth hormone (GH).

She inserted copies of this GH gene into plasmids. She then microinjected these recombinant plasmids into fertilised egg cells of zebrafish.

0 9 . 1

Describe how enzymes could be used to insert the GH gene into a plasmid.

[2 marks]

Restriction endonuclease used to cut enzyme with a 'sticky end'.

Ligase enzyme used to join desired DNA fragment cut with same restriction enzyme into plasmid, joining the sticky ends.

0 9 . 2

Microinjection of DNA into fertilised egg cells is a frequent method of producing transgenic fish. However, the insertion of the transferred gene into nuclear DNA may be delayed. Consequently, the offspring of transgenic fish may not possess the desired characteristic.

Suggest and explain how delayed insertion of the GH gene could produce offspring of transgenic fish without the desired characteristic.

[2 marks]

Cell division occurs before DNA insertion, so some daughter cells will not have desired genes replicated into them. Cells producing gametes do not receive the gene.



The scientist investigated whether the transferred *GH* gene increased the growth of transgenic zebrafish. She microinjected 2000 fertilised egg cells with the *GH* plasmid and left 2000 fertilised egg cells untreated. After 12 months, she determined the mean mass of the transgenic and non-transgenic fish.

The results the scientist obtained are shown in **Table 3**.

Table 3

A value of $\pm 2 \times \text{SD}$ from the mean includes over 95% of the data.

Type of zebrafish	Mean mass of zebrafish / g ($\pm 2 \times \text{SD}$)
Transgenic	1.79 (± 0.37)
Non-transgenic	0.68 (± 0.13)

09.3

Using **Table 3**, what can you conclude about the effectiveness of the *GH* gene on the growth of zebrafish?

[2 marks]

Standard deviations dont overlap, so difference is significantly different.

There is a significant difference in the mean mass of the fish. (Transgenic is heavier)

09.4

Explain how **two** features of the design of this investigation helped to ensure the validity of any conclusions obtained.

Do **not** include calculating the mean or SD in your answer.

[2 marks]

1 Control treatment used for comparison.

2 Large sample size allows high level of representation for all individuals.

8

Turn over ►



1 0

Read the following passage.

North American black bears can hibernate for up to 7 months without food or water. The bears survive using the fat stores in their bodies. The bears build up the fat stores during the summer. During hibernation, the heart rate of black bears decreases from a summer mean of 55 beats per minute to 14 beats per minute. Their metabolic rate falls by 75%.

5

In many mammals, 'uncoupling proteins' help to maintain a constant body temperature during hibernation. Uncoupling proteins are found in the inner mitochondrial membrane and act as proton channels during chemiosmosis. However, these proton channels do not generate ATP.

In the mountains of North America, when winter changes into spring, the coat colour of snowshoe hares changes from white to brown. Climatic changes have caused the snow to melt earlier. This has reduced the survival rate of snowshoe hares in these habitats. The change in coat colour occurs when new fur replaces old fur. This is called moulting. Recent research has shown that snowshoe hares within a population moult at different times. Moulting at different times could be a major factor in ensuring the survival of snowshoe hare populations.

10

15

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

1 0 . 1

Black bears can hibernate for up to 7 months without food or water (lines 1–2).

Suggest and explain how.

[3 marks]

Fat storages can be used up to metabolise and respire on. However, as inactive less energy is needed anyway. The process of gluconeogenesis allows fatty acids to be converted to glucose and used in respiration. They can also use less energy to respire due to high fat insulation keeping them warm. To conserve water they reduce urination and use water from metabolic processes, such as from respiration.



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1 0 . 2

During hibernation, the heart rate and the metabolic rate of black bears decrease (lines 3–5).

Use your knowledge of the nervous control of heart rate to describe how these are linked.

[4 marks]

Lower level of metabolism produces lower CO_2 concentration in the blood. Chemo receptors in the medulla register this and send less impulses from the cardiac centre. Fewer signal sent to SAN so heart rate slows as heart contracts less frequently.

1 0 . 3

In many mammals, 'uncoupling proteins' help to maintain a constant body temperature during hibernation (lines 6–7).

Suggest and explain how.

[2 marks]

They allow the movement of protons (H^+) from across the mitochondria membrane. Energy is released as heat, not generating ATP.

Question 10 continues on the next page

Turn over ►



1 0 . 4

Climatic change has reduced the survival rate of snowshoe hares in mountain habitats (lines 11–13).

Suggest and explain how.

[2 marks]

They rely on the snow at certain times of the year to ~~cover~~ camouflage them with their white fur. If there is no snow due to climate change hares will still be white easily spotted by predators. So more likely to fall as prey.

1 0 . 5

Snowshoe hares within a population moult at different times (line 15).

Explain how this could ensure the survival of snowshoe hare populations in these mountain habitats.

[4 marks]

Hares that moult earlier are having a survival advantage as less visible to predators. They are more likely to survive and reproduce, giving them a ~~survival~~ ~~to~~ reproductive success.

They then pass on their advantageous alleles to the next generation in their offspring.

Over time and generations frequency of advantageous allele increases in ~~the~~ the population

15

END OF QUESTIONS

