

Question 1

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).

box

0 8 . 1

Suggest how AS could cause proteinuria.

[2 marks]

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

☐

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]



Question 2

0 3

Nitrogen-fixing bacteria such as *Azotobacter chroococcum* use the enzyme nitrogenase to produce ammonia from nitrogen gas in the air. *A. chroococcum* can use ammonium chloride as a direct source of ammonia. When a source of ammonia is not available this bacterium uses nitrogen fixation.

A scientist investigated the effect of an increase in the concentration of ammonium chloride on the activity of nitrogenase in this bacterium. He prepared several liquid medium cultures of the bacterium. Each liquid culture had the same volume. He grew each culture in a different concentration of ammonium chloride.

In each culture:

- he recorded the nitrogenase activity in arbitrary units
- he removed the bacteria and then recorded the concentration of ammonium chloride remaining in each liquid medium.

Table 2 shows the scientist's results.

Table 2

Concentration of ammonium chloride / $\mu\text{g cm}^{-3}$	Nitrogenase activity / arbitrary units	Concentration of ammonium chloride remaining in liquid medium / $\mu\text{g cm}^{-3}$
0	45	0
20	30	0
40	17	0
60	7	0
80	0	6
100	0	14
120	0	20

0 3 . 1

Apart from temperature and pH, give **two** variables the scientist would have controlled when **preparing** the liquid medium cultures.

[2 marks]

1 _____

0 3 . 2

A student concluded that this investigation showed that ammonia inhibits nitrogenase activity in nitrogen-fixing bacteria. Use all the information to evaluate the student's conclusion.

[3 marks]

0 3 . 3

Nitrogenase catalyses the reduction of nitrogen during nitrogen fixation. The reaction requires 16 molecules of ATP for each molecule of nitrogen that is reduced. When ammonia inhibits nitrogenase activity, nitrogen-fixing bacteria may benefit. Explain how.

[2 marks]

box

continue on
box

Question 3

0 4 . 1 Complete the following definitions.

[2 marks]

The genome is _____

The proteome is _____

Recombinant DNA technology can involve the transfer of fragments of human DNA into bacteria. The bacteria are then used to produce human proteins.

0 4 . 2 Give **two** reasons why bacteria are able to use human DNA to produce human proteins.

[2 marks]

1 _____

2 _____

0 4 . 3 Suggest and explain **one** reason why bacteria might **not** be able to produce every human protein.

[1 mark]

Antithrombin is a protein. Antithrombin prevents blood from clotting too much. Some people have a deficiency of antithrombin in their blood, so they need to inject the protein.

Genetically modified goats are used to produce this protein. The human antithrombin gene is transferred into goat embryos. The adult goats then make human antithrombin protein.

Figure 7 shows an example of a DNA fragment that can be transferred into the cells of goats.

Figure 7



0 4 . 4 The enhancer stimulates region **M**.

Name regions **M** and **N** shown in **Figure 7**.

[2 marks]

Region **M** _____

Region **N** _____

box

outside the
box

0 4 . 5 Explain the purpose of the marker gene.

[1 mark]

0 4 . 6 The enhancer only stimulates region **M** in the milk-producing glands of a goat.

Suggest **two** explanations for the importance of the enhancer being included in the DNA fragment transferred.

[2 marks]

Question 4

0 3

A student investigated the effects of indoleacetic acid (IAA) on the growth of oat seedlings (young plants).

The student:

- removed the shoot tip from each seedling and cut out a 10 mm length of shoot
- placed 10 lengths of shoot into each of 5 Petri dishes
- added to each Petri dish an identical volume of 5% glucose solution
- added to each Petri dish 40 cm³ of a different concentration of IAA solution
- left the Petri dishes at 20 °C in the dark with their lids on for 5 days
- removed the shoots after 5 days and measured them
- determined the mean change in length of shoot at each concentration of IAA.

Table 1 shows her results.

Table 1

IAA concentration added to Petri dish / parts per million	10 ⁻⁵	10 ⁻³	10 ⁻¹	1	10
Mean change in length of shoot / mm	0.0	0.1	1.3	2.4	3.1

0 3 . 1

Explain why the student removed the shoot tip from each seedling.

[2 marks]

0 3 . 2

Explain why the student added glucose solution to each Petri dish.

[2 marks]

0 3 . 3

Explain why the lids were kept on the Petri dishes.

[2 marks]

0 3 . 4

Describe and explain the results shown in **Table 1** and suggest how the results might have differed if lengths of **root** had been used.

[3 marks]

box

continue the box

03.5

The student produced the different concentrations of IAA using a stock 1 g dm^{-3} solution of IAA ($1\text{ g dm}^{-3} = 1$ part per thousand) and distilled water.

Complete **Table 2** with the volumes of stock IAA solution and distilled water required to produce 40 cm^3 of 10 ppm (parts per million) IAA solution.

[1 mark]

Table 2

Concentration of IAA solution / parts per million	Volume of stock IAA solution / cm^3	Volume of distilled water / cm^3
10		

calculate the box

10

Question 5

0 1 . 1 Exercise causes an increase in heart rate.

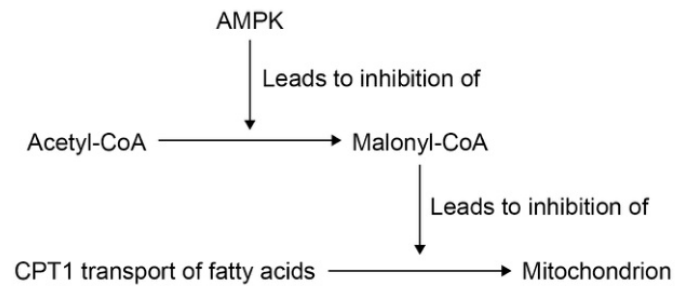
Describe the role of receptors and of the nervous system in this process.

[4 marks]

0 1 . 2 AMP-activated protein kinase (AMPK) is an enzyme that regulates a number of cellular processes. Exercise leads to activation of AMPK.

Figure 1 shows one effect of activation of AMPK during exercise.

Figure 1



CPT1 is a channel protein that transports fatty acids into mitochondria.

Using **Figure 1**, explain the benefit of activation of AMPK during exercise.

[3 marks]

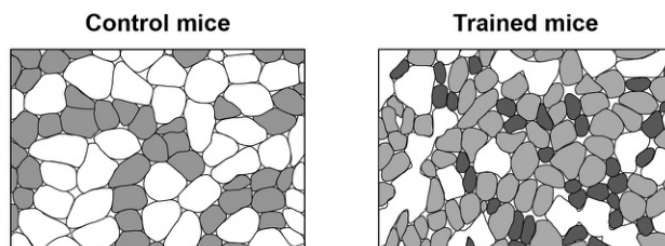
Question 6

0 3

Scientists investigated the effect of regular exercise on skeletal muscle fibres in mice. The scientists compared the muscle fibres of mice after six weeks of regular exercise (trained mice) with those of mice that had not exercised (control mice). The scientists stained the muscle fibres from both sets of mice to show succinic acid dehydrogenase activity. The darker the stain the greater the succinic acid dehydrogenase activity.

Figure 3 shows a typical set of results they obtained.

Figure 3



0 3 . 1

Succinic acid dehydrogenase is an enzyme used in the Krebs cycle.

Suggest **one** reason for the difference in the staining between the muscle fibres of the control mice and the trained mice.

[1 mark]

0 3 . 2

The scientists then compared the length of time that the control mice and the trained mice could carry out prolonged exercise. The trained mice were able to exercise for a longer time period than control mice.

Explain why.

[3 marks]

0 3 . 3

The scientists determined the mean diameter of muscle fibres in trained mice using an optical microscope to examine sections of muscle tissue. The circular area (πr^2) of one field of view was 1.25 mm^2 . The diameter of this area was equal to the diameter of 15 muscle fibres.

Using this information, calculate the mean diameter in μm (micrometres) of muscle fibres in this section of tissue.

[2 marks]

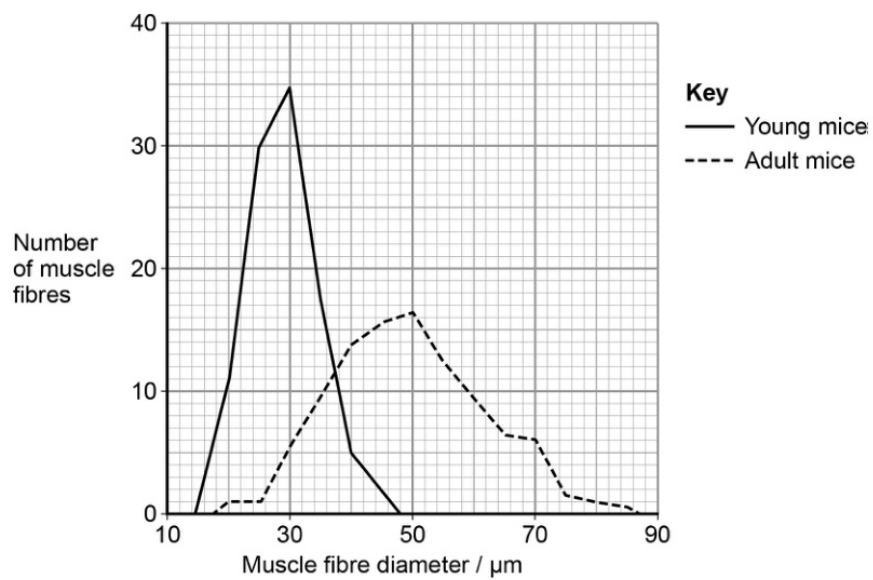
Answer = _____ μm

0 3 . 4

The scientists also compared the diameter of samples of muscle fibres taken from young mice and adult mice.

Some of their results are shown in **Figure 4**.

Figure 4



Describe **two** differences between these samples of muscle fibres.

[2 marks]

- 1 _____

- 2 _____

Question 7

0 1

Heat stress is a condition that often occurs in plants exposed to high temperatures for a prolonged period of time. Heat stress is a major factor in limiting the rate of photosynthesis.

0 1 . 1

Heat stress decreases the light-dependent reaction of photosynthesis.

Explain why this leads to a decrease in the **light-independent reaction**.

[2 marks]

0 1 . 2

Another effect of heat stress is a decrease in the activity of the enzyme rubisco. A decrease in the activity of an enzyme means that the rate of the reaction it catalyses becomes slower.

A decrease in the activity of the enzyme rubisco would limit the rate of photosynthesis.

Explain why.

[2 marks]

0 1 . 3

Where precisely is rubisco found in a cell?

[1 mark]

Scientists investigated the effect of temperature on the activity of two enzymes isolated from the leaf cells of cotton plants.

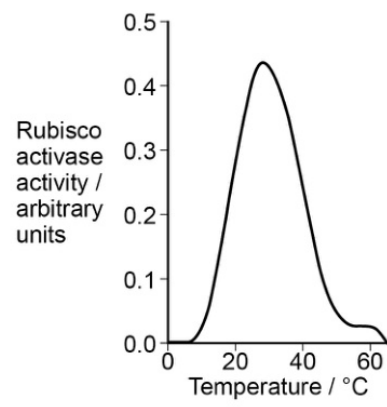
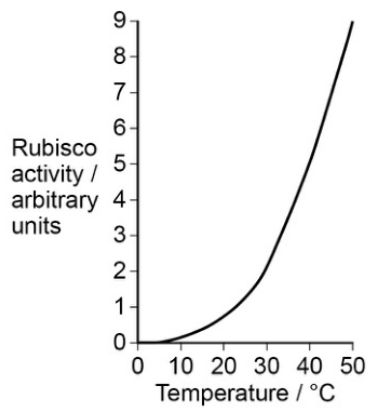
- Rubisco
- Rubisco activase – an enzyme that activates rubisco

Figure 1 and **Figure 2** show their results.

Figure 1

Figure 2

checked the box



0 1 . 4

The scientists concluded that heat stress reduces the activity of rubisco in plant leaves by affecting rubisco activase.

Use all the information to evaluate their conclusion.

[4 marks]

Question 8

1 0

Read the following passage.

box

Lake Malawi in East Africa has more species of fish than any other lake in the world. Many of these species have evolved from a common ancestor. Lake Malawi is one of the largest lakes in the world and was formed several million years ago. Since then, the water level has fluctuated greatly. As a result, what is now a large lake was at one time many smaller, separate lakes. 5

The country of Malawi has a total area of 118 000 km². The actual land area is only 94 080 km², because approximately one-fifth of the country is Lake Malawi.

In December 1990, forests covered 41.4% of the actual land area of Malawi. In December 2016, forests covered 26.4% of the actual land area of Malawi. 10

Deforestation and farming along the shores of Lake Malawi have caused increased soil erosion and loss of nutrients into the lake. This has resulted in a decrease in some fish populations. The mark-release-recapture method can be used to estimate the size of a fish population. However, this method can produce unreliable results in very large lakes. 15

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

1 0 . 1

Lake Malawi in East Africa has more species of fish than any other lake in the world (line 1).

Suggest and explain how this speciation may have occurred.

[4 marks]

1 0 . 2

The percentage of forest cover in Malawi decreased between December 1990 and December 2016 (lines 9–10).

Calculate the mean loss of forest cover in km² per week during this time period.

[2 marks]

Answer _____ km² per week

1 0 . 3

Loss of nutrients **into** Lake Malawi has resulted in a decrease in some fish populations (lines 12–13).

Explain why.

[4 marks]

1 0 . 4

The mark-release-recapture method can be used to estimate the size of a fish population (lines 13–14).

Explain how.

[4 marks]

generate the box

generate the box

10.5

Suggest why the mark-release-recapture method can produce unreliable results in very large lakes (lines 14–15).

[1 mark]

END OF QUESTIONS

Question 9

1 0

Read the following passage.

box

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]



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]

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]

Question 10 continues on the next page

Turn over ►



2 5
1 0 . 4

IB/M/Jun20/7402/2

use the
box

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

Suggest and explain how.

[2 marks]

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]

15

END OF QUESTIONS



2 6

IB/M/Jun20/7402/2