Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

BIOLOGY **9700/42**

Paper 4 A Level Structured Questions **February/March 2018**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **one** question.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

DC (LK/FC) 148471/3

Section A

Answer **all** questions.

1 (a) The aye-aye, *Daubentonia madagascariensis,* is a primate native to Madagascar. Aye-ayes are nocturnal (active at night) and make their nests high up in trees. They feed on insect larvae in the trunks of trees.

Fig. 1.1 shows an aye-aye.

Fig. 1.1

The International Union for Conservation of Nature (IUCN) is the world's largest global environmental organisation. The IUCN Red List of Threatened Species™ evaluates the conservation status of plant and animal species.

The aye-aye is categorised as endangered on the IUCN Red List, which means that it faces a very high risk of becoming extinct in the wild.

(i) Name the domain to which the aye-aye belongs.

.....[1]

(ii) Suggest **one** reason why aye-ayes have become endangered.

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.....[1]

(iii) Suggest ways in which zoos may help to protect this species from extinction.

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Question 1 continues on page 4

(b) There are two main aye-aye populations on the island of Madagascar, one in the west and one in the east.

Fig. 1.2 is a map of Madagascar showing the location of the two main populations.

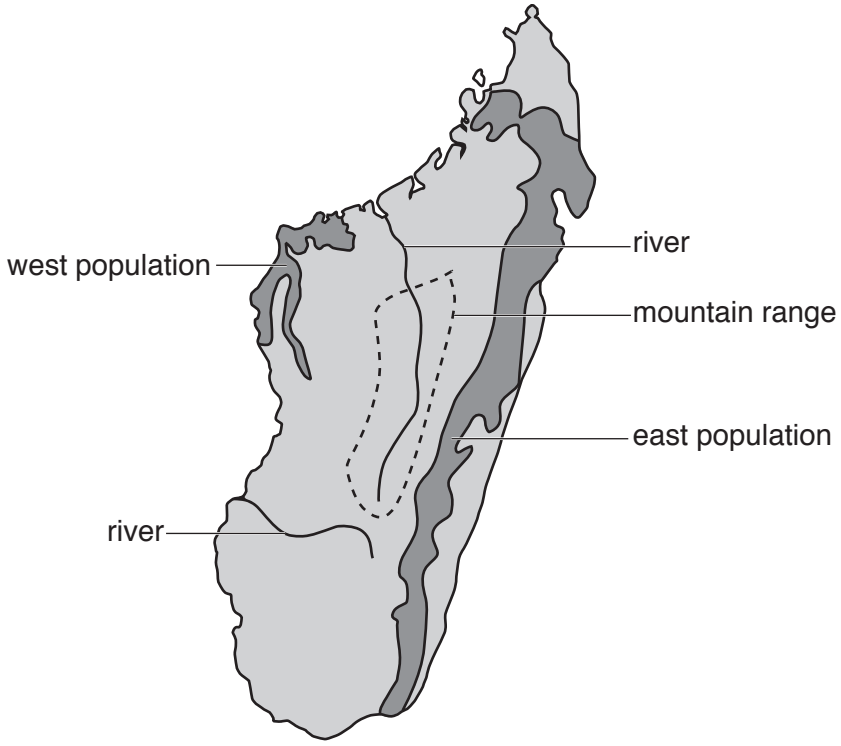

Fig. 1.2

A study into the variation in the DNA nucleotide sequence of aye-ayes showed that there is a large genetic difference between the west and east populations. The two populations of aye-ayes may be evolving into separate species.

(i) With reference to Fig. 1.2, suggest why there is a large genetic difference between the two populations.

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(ii) Name the type of speciation that may be occurring.

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(iii) Suggest **and** explain a pre-zygotic isolating mechanism that could prevent successful reproduction between aye-ayes of the two populations.

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[Total: 12]

[Turn over

2 Motor neurones are cells within the nervous system.

(a) Fig. 2.1 shows a diagram of a motor neurone.

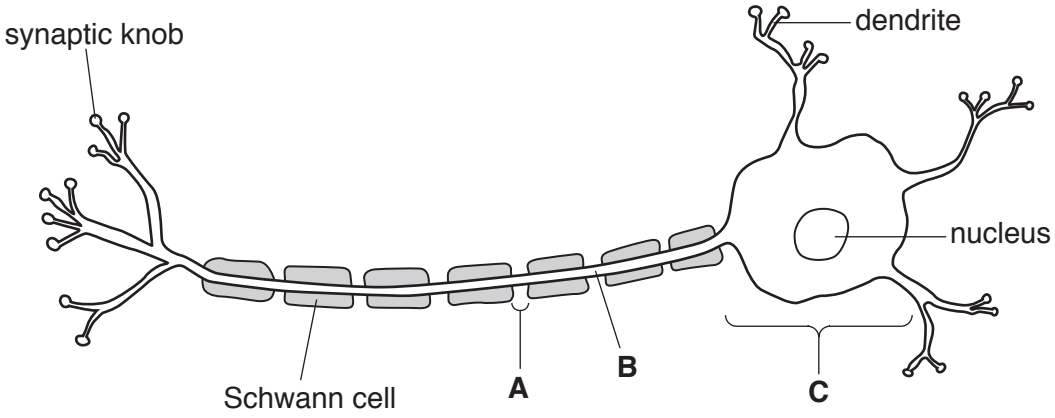

Fig. 2.1

(i) Name the structures labelled **A**, **B** and **C** on Fig. 2.1.

A .....

B .....

C .....

[3]

(ii) Describe the function of a motor neurone in a reflex arc.

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.....[2]

(b) Fig. 2.2 shows a picture of a blue whale, *Balaenoptera musculus*. Blue whales are the largest living mammals and have motor neurones of the type shown in Fig. 2.1. These motor neurones can be up to 30 metres long. The speed of nerve impulses along this type of motor neurone is fast.

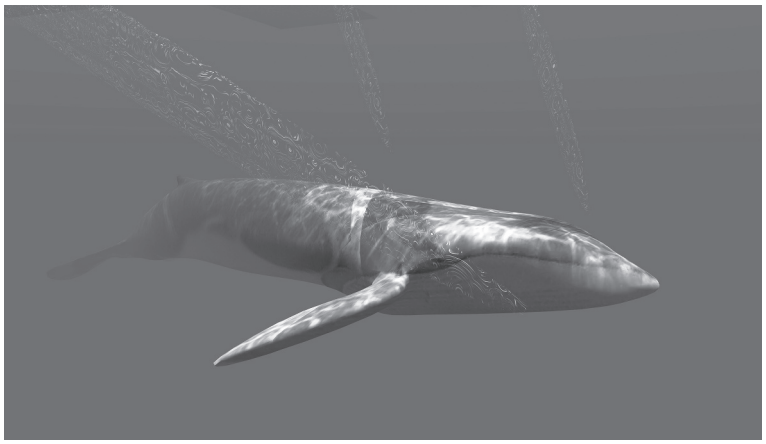

Fig. 2.2

(i) With reference to Fig. 2.1, explain the fast transmission of impulses along this type of motor neurone.

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(ii) Suggest why fast transmission of nerve impulses is particularly important in the blue whale.

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[Total: 10]

3 The β-globin gene codes for the β-globin polypeptide of haemoglobin. It has two alleles, $\mathbf{Hb^A}$ (normal) and $\mathbf{Hb^S}$ (sickle cell). The sickle cell allele differs from the normal allele due to a base substitution mutation and this mutation results in a single amino acid change to the β-globin polypeptide.

There are three possible genotypes and phenotypes.

- $\mathbf{Hb^S\ Hb^S}$, sickle cell anaemia, a severe disease
- $\mathbf{Hb^A\ Hb^S}$, sickle cell trait with mild or no symptoms of sickle cell anaemia
- $\mathbf{Hb^A\ Hb^A}$, normal (healthy)

A man and woman who both have sickle cell trait may choose to have children by IVF. This allows the genotype of embryos to be determined by gene testing before the embryos are implanted. Embryos with the normal genotype can then be selected and implanted into the mother.

One technique that can be used in gene testing an embryo for the $\mathbf{Hb^S}$ allele is restriction fragment length polymorphism (RFLP) analysis. This involves digesting a DNA sample from an embryo with a restriction endonuclease and then separating the DNA fragments by gel electrophoresis. The position of the DNA fragments on the gel can show if the embryo has the $\mathbf{Hb^S}$ allele.

(a) The first step in testing an embryo for the $\mathbf{Hb^S}$ allele by RFLP analysis requires many copies of the part of the β-globin gene in which the mutation causing sickle cell anaemia occurs.

(i) Name the technique used to produce many copies of a DNA sequence from a very small quantity of DNA.

.....[1]

(ii) Explain why it is necessary to copy this DNA sequence many times in order to test embryos for $\mathbf{Hb^S}$ alleles by RFLP analysis.

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.....[1]

In the next step of RFLP analysis, the copies of the part of the β-globin gene from the first step are incubated with a restriction endonuclease, *Mst*II. This enzyme cuts at a specific sequence of DNA (the restriction site).

The restriction site for *Mst*II is shown in Fig. 3.1.

5' – C C T N A G G – 3'
3' – G G A N T C C – 5' N = any nucleotide (A, T, C or G)

Fig. 3.1

Fig. 3.2 shows the part of an **Hb^A** allele obtained from the first step. All the *Mst*II restriction sites and the number of DNA base pairs separating these restriction sites are shown.

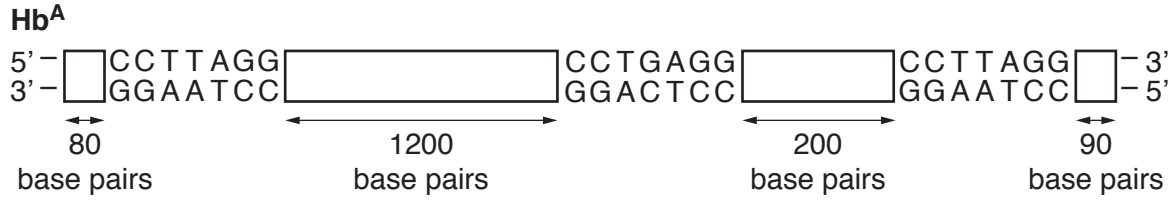

Fig. 3.2

Fig. 3.3 shows the same part of an **Hb^S** allele. The single base substitution in the **Hb^S** allele that causes sickle cell anaemia is indicated.

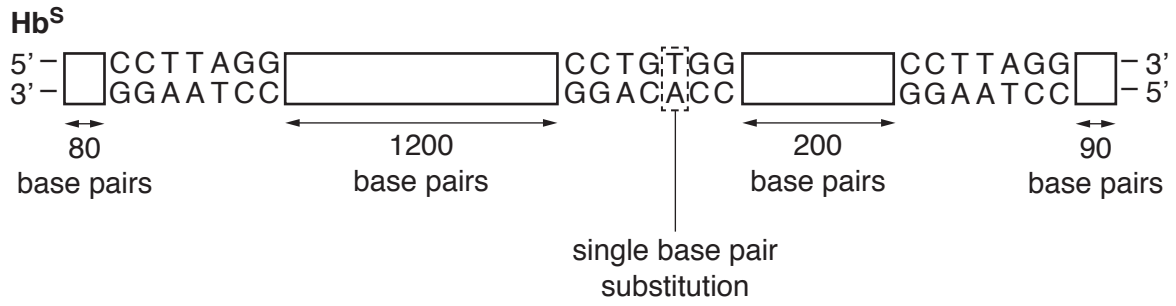

Fig. 3.3

(b) With reference to Fig. 3.1, Fig. 3.2 and Fig. 3.3, explain why the enzyme *Mst*II can be used in RFLP analysis to show the difference between these parts of the **Hb^A** and **Hb^S** alleles.

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(c) After cutting with *Mst*II, the DNA fragments are separated by gel electrophoresis.

Explain how gel electrophoresis separates DNA fragments cut with restriction endonucleases.

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.....[3]

(d) Four embryos, **1**, **2**, **3** and **4**, were tested for the **Hb^S** allele using RFLP analysis. Fig. 3.4 shows the DNA fragments separated by gel electrophoresis for the four embryos. The DNA fragments for two individuals of known genotype, homozygous for **Hb^A** and homozygous for **Hb^S**, are also shown.

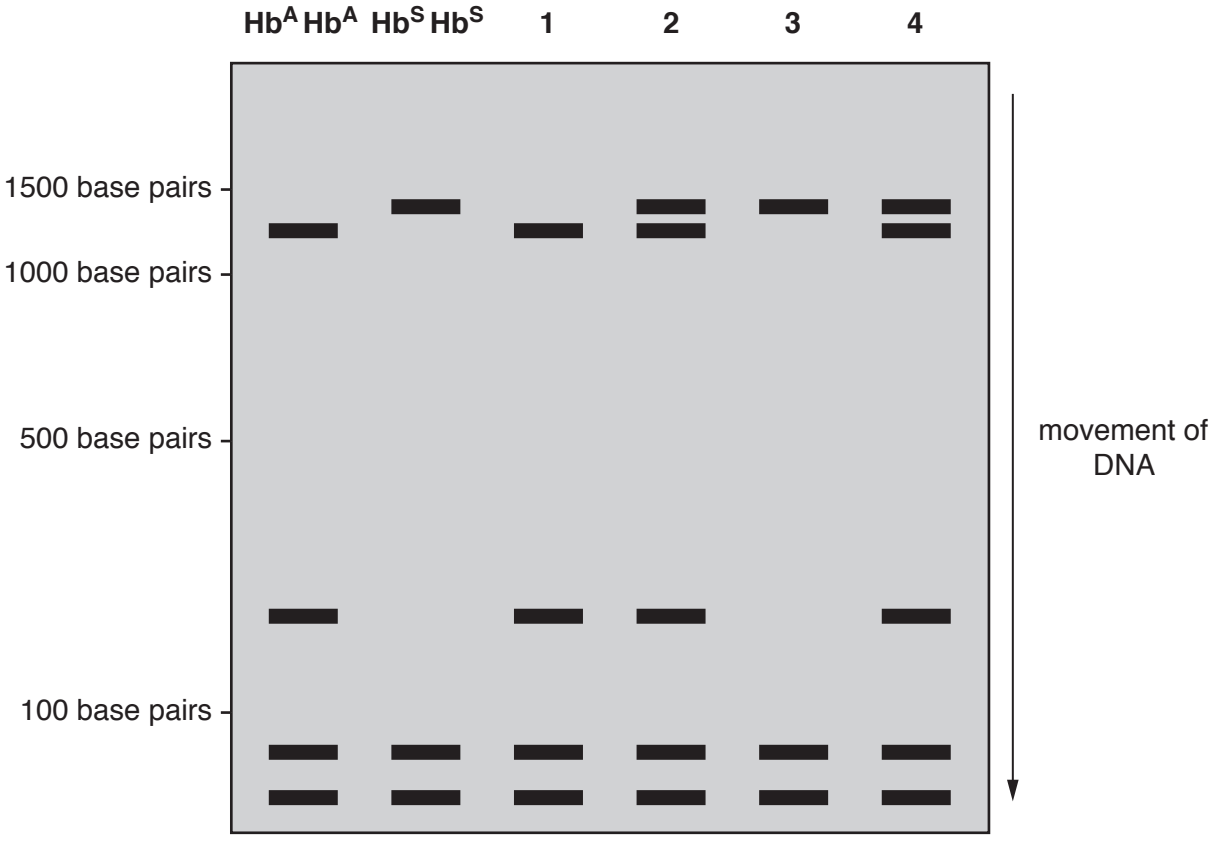

Fig. 3.4

(i) State the purpose of using DNA from individuals homozygous for $\mathbf{Hb^A}$ and for $\mathbf{Hb^S}$.

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.....[1]

(ii) With reference to Fig. 3.4, complete Table 3.1 to show the genotypes of embryos **2**, **3** and **4**.

Table 3.1

embryo	genotype
1	$\mathbf{Hb^A\ Hb^A}$
2	
3	
4	

[2]

(e) Discuss the ethical and social considerations of gene testing embryos for genetic diseases.

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.....[3]

[Total: 15]

4 Ribulose 1,5-bisphosphate carboxylase/oxygenase (rubisco) is an important enzyme involved in the light independent stage (Calvin cycle) of photosynthesis. It fixes carbon by combining carbon dioxide with RuBP.

In certain situations, the active site of rubisco becomes occupied by a sugar phosphate, making the enzyme inactive. Rubisco can become active again in the presence of another enzyme, rubisco activase.

(a) Name all the bonds that are likely to hold a molecule of rubisco in shape.

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.....[2]

(b) Suggest how rubisco activase can activate rubisco.

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.....[1]

(c) C4 plants such as maize have adaptations that allow them to have high rates of carbon fixation at high temperatures. Without these adaptations, some plants (C3 plants) are affected at high temperatures by a process known as photorespiration.

In photorespiration, rubisco combines oxygen with RuBP. This leads to a decrease in the rate of photosynthesis.

(i) Describe **and** explain how the anatomy of the leaves of C4 plants such as maize allows them to have high rates of carbon fixation at high temperatures.

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.....[3]

(ii) In C3 plants, the rate of photorespiration increases at high light intensities as well as at high temperatures.

Suggest why the rate of photorespiration increases at high light intensities in C3 plants.

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.....[2]

(iii) Explain why the rate of photosynthesis decreases as a result of photorespiration in C3 plants.

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.....[2]

[Total: 10]

5 **(a)** The contraction of striated muscle is explained by the sliding filament model.

(i) Describe what happens in the sarcomere when the myosin head releases ADP and inorganic phosphate (Pi).

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.....[1]

(ii) Explain the **precise** function of ATP in the sliding filament model.

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(b) During contraction, muscles use up ATP very quickly. For a short period of time, ATP can be resynthesised using creatine phosphate, as shown in Fig. 5.1.

ADP + creatine phosphate ⟶ ATP + creatine

Fig. 5.1

The creatine formed as a result of the resynthesis of ATP is converted to creatinine. Creatinine production in the body stays fairly constant. Creatinine becomes part of the glomerular filtrate during ultrafiltration in the kidney nephrons.

(i) Ultrafiltration requires a high blood pressure in the glomerulus.

Explain how this high blood pressure is achieved.

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.....[1]

(ii) Name the main filtration barrier in the nephron that allows creatinine to pass into the renal capsule but stops red blood cells from passing through.

.....[1]

Question 5 continues on page 16

(c) The concentration of creatinine in the blood largely depends on the glomerular filtration rate (GFR). By measuring the concentration of creatinine in the blood, the GFR can therefore be estimated. The value of the GFR can be used to assess the efficiency of the kidneys.

In humans, a normal value of the GFR is 100 $cm^3 min^{-1}$.

Fig. 5.2 shows the relationship between the GFR and the concentration of creatinine in the blood.

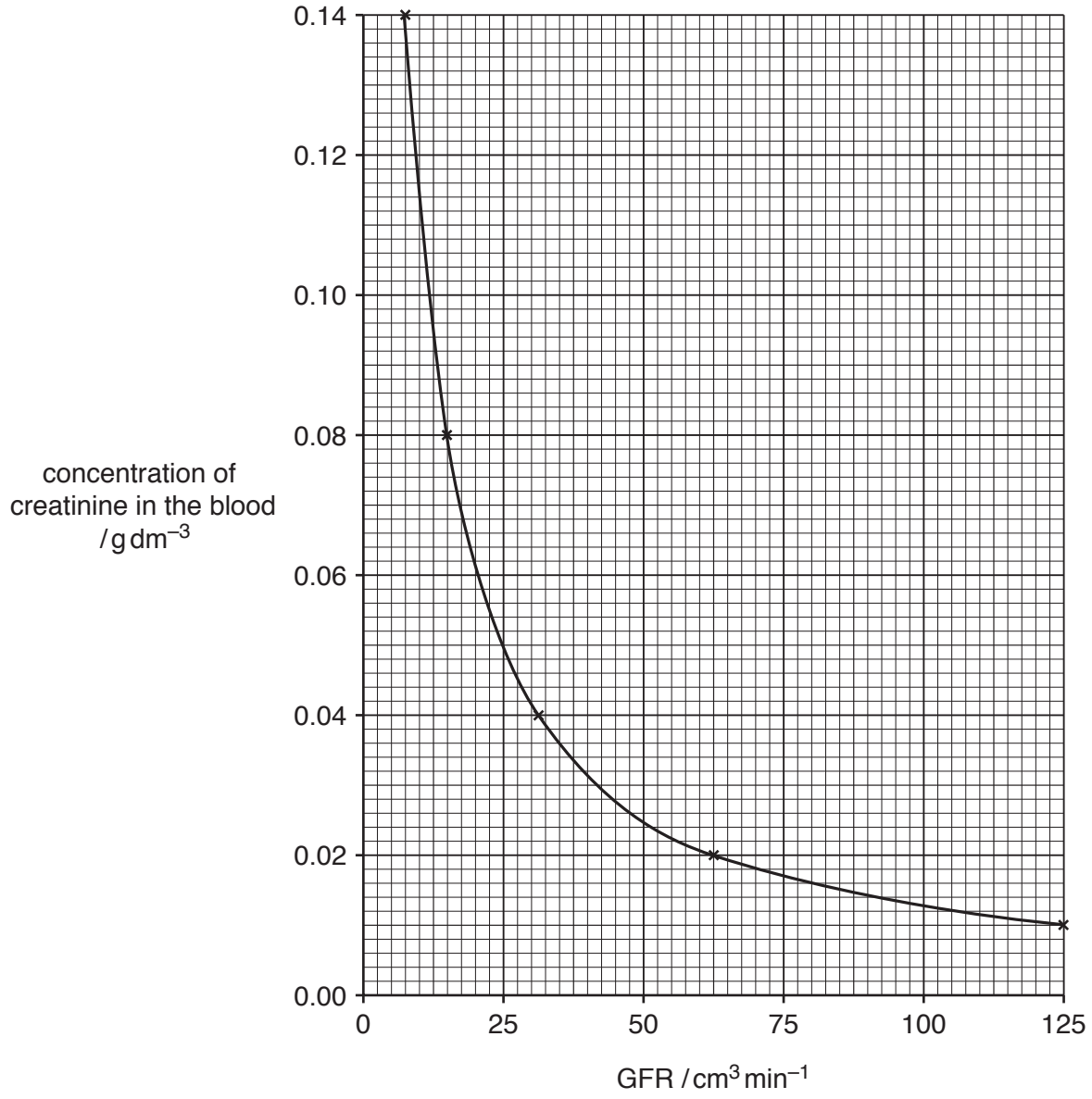

Fig. 5.2

(i) Describe the relationship shown in Fig. 5.2.

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.....[2]

(ii) Use Fig. 5.2 to estimate the concentration of creatinine in the blood that indicates a normal GFR.

answer .....[2]

(iii) Suggest **two** reasons why the GFR could decrease.

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.....[2]

[Total: 12]

6 The black pigment melanin, which contributes to hair, skin and eye colour, is produced by cells known as melanocytes.

(a) In people with albinism, the melanocytes do not produce melanin. Albinism is caused by an inherited gene mutation.

(i) Outline how a gene mutation may occur.

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.....[4]

(ii) Albinism is an autosomal recessive condition.

Explain what is meant by the term *recessive*.

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.....[1]

(iii) Using appropriate symbols, draw a genetic diagram to show how a man and a woman, who both produce melanin, could have a child with albinism.

[3]

(b) Melanin is produced by the action of the enzyme tyrosinase on the amino acid tyrosine.

A study was carried out to investigate the effect of an extract of the starfish *Patiria pectinifera* on the activity of tyrosinase.

Table 6.1 shows the results of this study.

Table 6.1

concentration of starfish extract / $\mu g\,cm^{-3}$	percentage tyrosinase activity
0	100
4	90
8	77
16	68
32	56
64	46
128	32

Suggest how the starfish extract affects the activity of tyrosinase.

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.....[3]

[Total: 11]

7 **(a)** Fig. 7.1 shows a red deer, *Cervus elaphus*. Red deer are herbivores that feed on a wide range of plants.

Fig. 7.1

The number of red deer in the UK increased between 1960 and 2010, as shown in Table 7.1.

Table 7.1

year	number
1960	135 000
1970	180 000
1980	250 000
1990	300 000
2000	330 000
2010	360 000

(i) Calculate the percentage increase in red deer in the UK from 1960 to 2010.

Give your answer to one decimal place.

answer ..... %
[2]

(ii) Environmental factors affect the population size of red deer so that numbers do not continue to increase forever.

Suggest environmental factors that may prevent further increase in the size of a red deer population.

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.....[3]

(b) The body mass of red deer shows wide variation within populations and this variation is shown in Fig. 7.2.

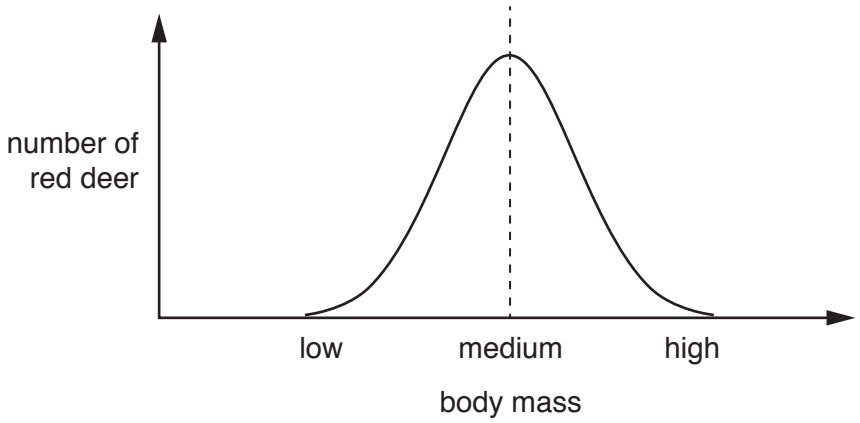

Fig. 7.2

(i) A selection pressure acted consistently over many years against red deer of **low** body mass in a population.

Sketch a curve on Fig. 7.3 to show the pattern of variation of body mass in this red deer population after this time **and** name the type of force of natural selection that is acting.

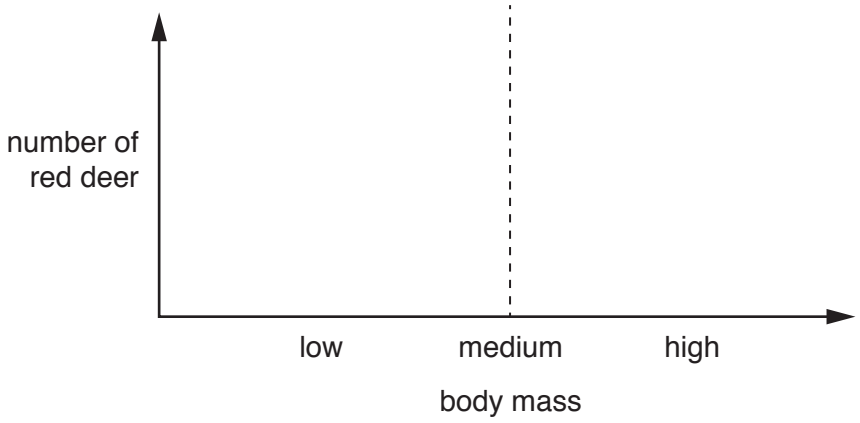

Fig. 7.3

type of force of natural selection .....
[2]

(ii) A selection pressure acted consistently over many years against red deer of **medium** body mass in a different population.

Sketch a curve on Fig. 7.4 to show the pattern of variation of body mass in this red deer population after this time **and** name the type of force of natural selection that is acting.

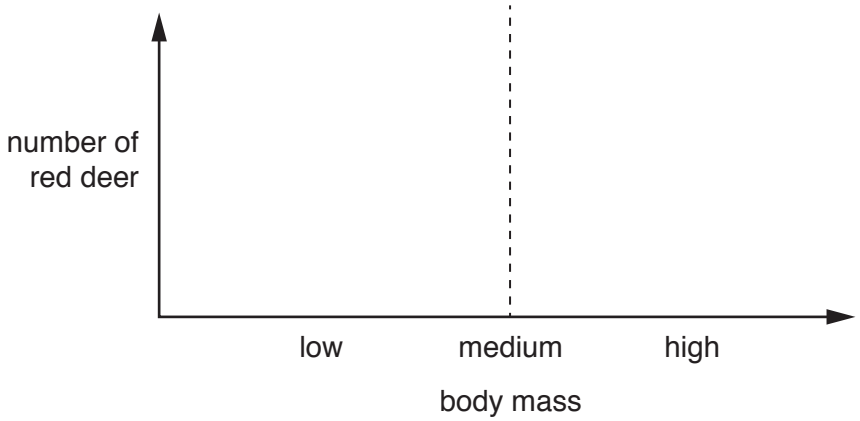

Fig. 7.4

type of force of natural selection .....
[2]

[Total: 9]

8 Structures and compounds involved in respiration include:

1 coenzyme A

2 cytoplasm

3 pyruvate

4 NAD

5 outer mitochondrial membrane

6 carrier protein

7 inner mitochondrial membrane

8 intermembrane space of mitochondrion

9 ADP

10 acetyl group

Match each of the descriptions with **one** number chosen from **1** to **10**, to show the correct structure or compound.

You may use each number once, more than once or not at all.

location of ATP synthase .....

transports hydrogen atoms .....

nucleotide with a purine base .....

location of substrate-linked phosphorylation .....

enters the Krebs cycle .....

produced by oxidation of triose phosphate .....

[6]

[Total: 6]

Section B

Answer **one** question.

9 **(a)** Describe the process of **cyclic** photophosphorylation **and** the structure of the photosystem involved. [9]

(b) Explain how **non-cyclic** photophosphorylation produces reduced NADP **and** how reduced NADP is used in the light independent stage. [6]

[Total: 15]

10 **(a)** Explain the role of auxin in cell elongation. [8]

(b) Explain, using examples, how the environment may affect the phenotype of individual organisms. [7]

[Total: 15]

[Turn over