Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

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0123456789

BIOLOGY **9700/04**

Paper 4 A Level Structured Questions **For examination from 2022**

SPECIMEN PAPER **2 hours**

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 100.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **26** pages. Blank pages are indicated.

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1 **(a)** The aye-aye, *Daubentonia madagascariensis*, is a mammal, native to Madagascar. Aye-ayes are 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) categorises the aye-aye as endangered. This means that the aye-aye has a very high risk of becoming extinct in the wild.

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

..... [1]

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

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..... [1]

(iii) Suggest ways in which ø os may be able to protect this species from extinction.

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..... [3]

(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.

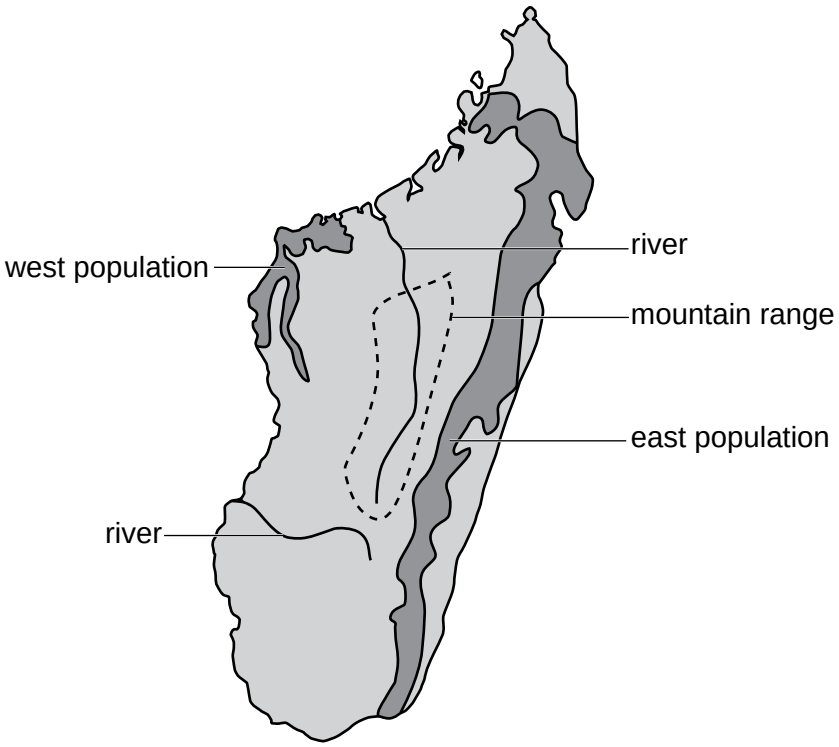

Fig. 1.2

A study into the variation in the DNA nucleotide sequence of aye-ayes showed that there is a large genetic difference between the west population and east population. 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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..... [5]

(ii) Name the type of speciation that is most likely to occur.

..... [1]

[Total: 11]

2 Fig. 2.1 shows a diagram of a motor neurone.

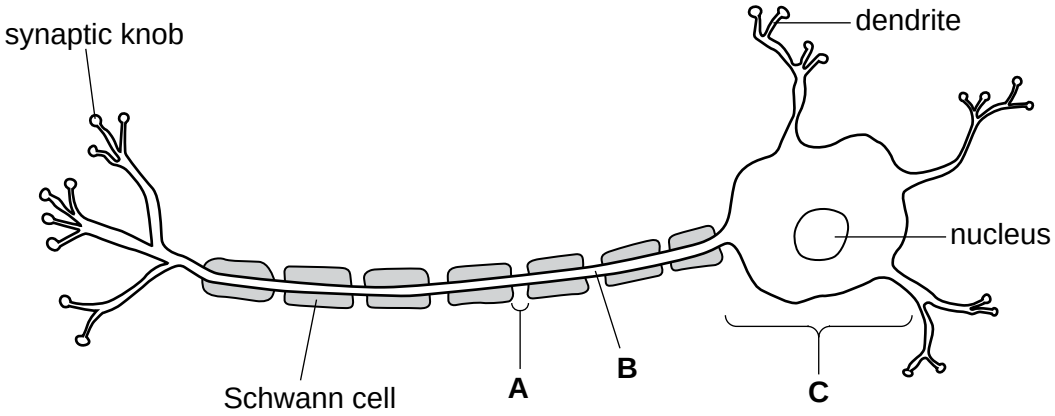

Fig. 2.1

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

A .....

B .....

C .....

[3]

(b) Describe the function of a motor neurone.

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..... [2]

(c) With reference to Fig. 2.1, explain the fast transmission of impulses along a motor neurone.

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..... [4]

[Total: 9]

3 Corals grow in shallow sea water. Corals consist of colonies of small animals called polyps. These polyps have photosynthetic protoctists called algae within their cells, which is advantageous both to the coral polyps and to the algae.

The algae that live within the cells of coral polyps can also live independently as free-living algae.

(a) The rate of photosynthesis of algae that live within the cells of coral polyps is higher than that of free-living algae.

Suggest **and** explain why the rate of photosynthesis in algae that live within the cells of coral polyps is higher than that of free-living algae.

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..... [3]

(b) The algae that live within the cells of coral polyps have five different chloroplast pigments.

Table 3.1 shows the light wavelengths at which each algal chloroplast pigment shows its two largest peaks of light absorption.

Table 3.1

chloroplast pigment	peak 1 wavelength / nm	peak 2 wavelength / nm
chlorophyll *a*	430	662
peridinin	456	485
chlorophyll c_2	450	396
dinoxanthin	442	471
β-carotene	454	480

Corals can be kept in glass tanks that are usually lit by lamps radiating mainly violet and blue light, with wavelengths in the range of 400 nm to 490 nm.

With reference to Table 3.1, suggest why lamps radiating mainly violet and blue light are expected to increase the growth of **coral polyps** more than lamps radiating light of all wavelengths.

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..... [3]

(c) Photosynthesis in the algae living within the cells of coral polyps is the same as photosynthesis in plant cells.

Outline the process of cyclic photophosphorylation.

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..... [4]

[Total: 10]

Question 4 starts on page 12

4 The polymerase chain reaction (PCR) is used to produce large quantities of DNA from a very small original sample. The main steps of one PCR method are shown in Fig. 4.1.

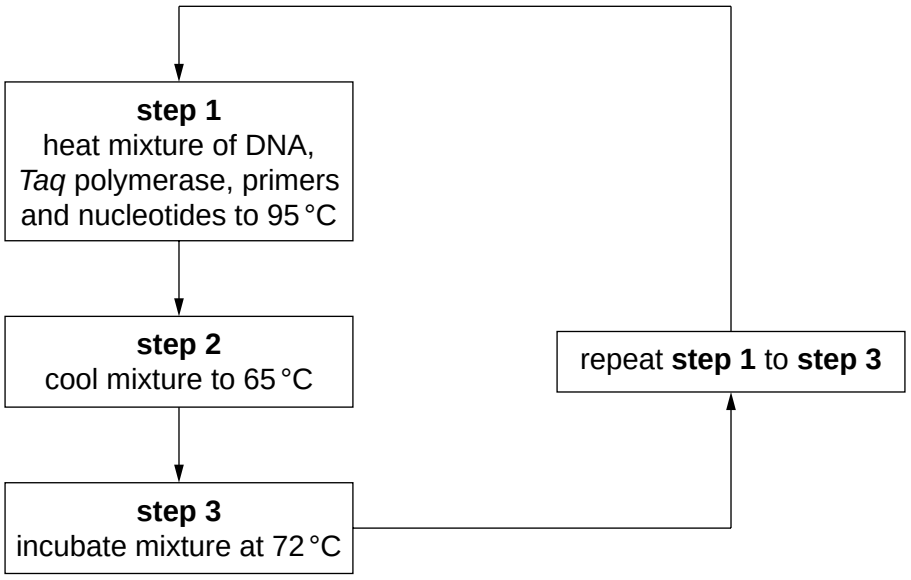

Fig. 4.1

(a) (i) Explain why it is necessary to heat the mixture to 95 °C (**step 1**).

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..... [2]

(ii) Explain why primers are included in the mixture.

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..... [2]

(iii) Explain why the enzyme *Taq* polymerase, rather than any other type of DNA polymerase, is used in PCR.

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..... [2]

(b) The presence of a faulty allele of the gene *BRCA2* can lead to an increased chance of developing breast cancer. There are many different faulty alleles of the gene *BRCA2*.

People who are considered to be at risk of breast cancer may choose to be tested for the presence of these alleles in their genomes.

A microarray can be used to test blood samples for the presence of these alleles. The microarray contains DNA probes for different faulty alleles of the *BRCA2* gene.

(i) State the meaning of the term genome.

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..... [1]

(ii) Suggest which type of cell from a blood sample is suitable for testing for the presence of these faulty alleles.

Give a reason for your choice.

type of cell .....

reason .....

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[1]

(iii) Outline how faulty alleles of the *BRCA2* gene can be detected using the microarray.

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..... [4]

(iv) Outline the advantages of screening for faulty alleles of the *BRCA2* gene.

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..... [4]

[Total: 16]

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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..... [3]

(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 Bowman's capsule but stops red blood cells from passing through.

..... [1]

(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.

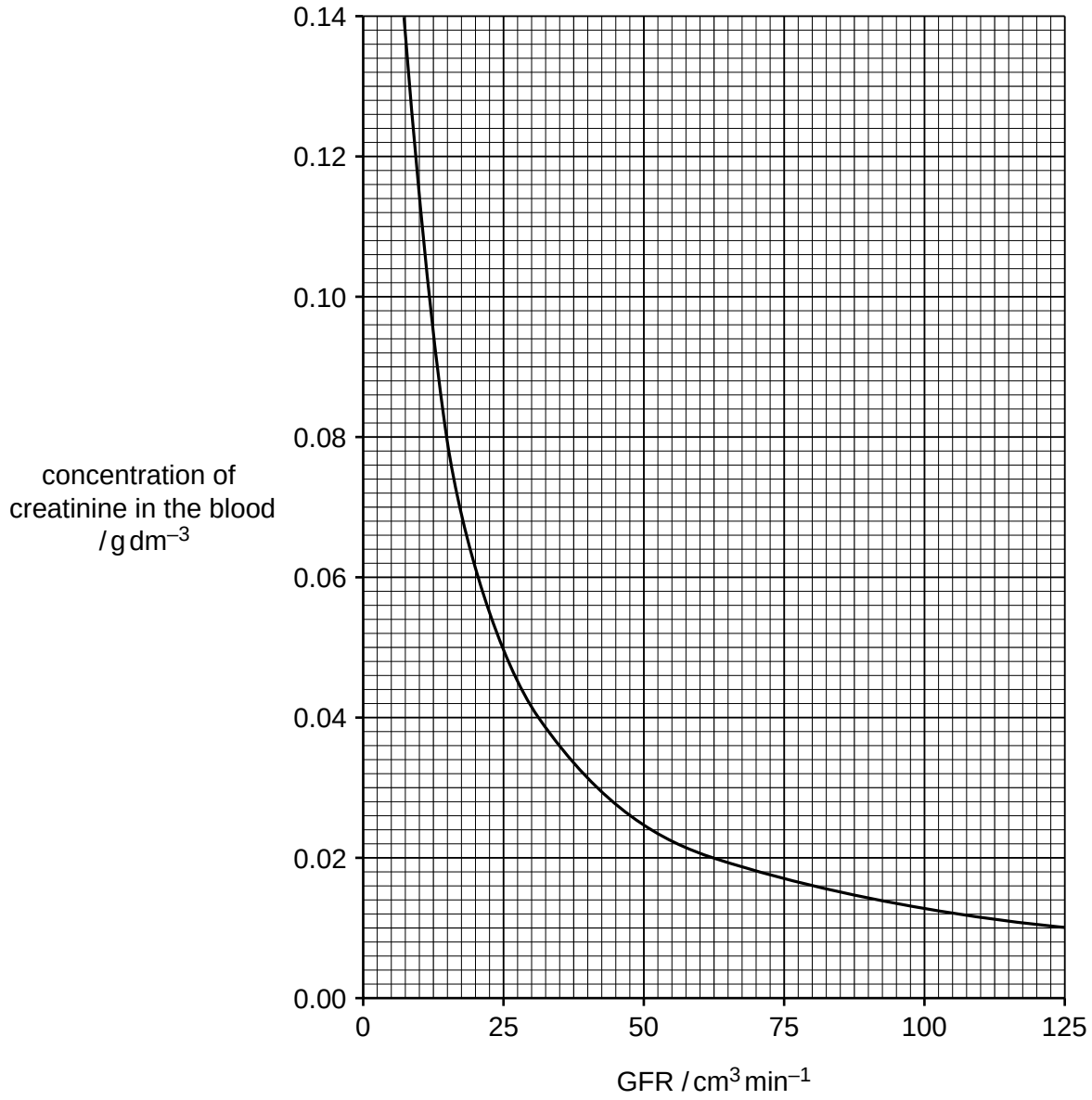

Fig. 5.2

(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.

concentration = ... [2]

(iii) Suggest **two** reasons why the GFR of a person might decrease.

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..... [2]

[Total: 12]

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

(a) Tyrosinase is an enzyme involved in the production of melanin.

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 / μg cm^{-3}	percentage activity of tyrosinase
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]

(b) The dominant allele of the *TYR* gene codes for the enzyme tyrosinase.

In people with albinism, the melanocytes do not produce melanin. This is caused by a recessive allele of the *TYR* gene.

(i) Explain what is meant by the terms recessive and allele.

recessive .....

.....

allele .....

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[2]

(ii) Construct a genetic diagram to show how a man and a woman, who both produce melanin, could have a child with albinism.

Use appropriate symbols in your answer **and** state what they represent.

[3]

[Total: 8]

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

Fig. 7.1

The number of red deer in the UK increased from 135 000 in 1960 to 360 000 in 2010.

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

Suggest environmental factors that may prevent further increases in the size of red deer populations.

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..... [3]

The body mass of red deer shows wide variation within a population. This is shown in Fig. 7.2.

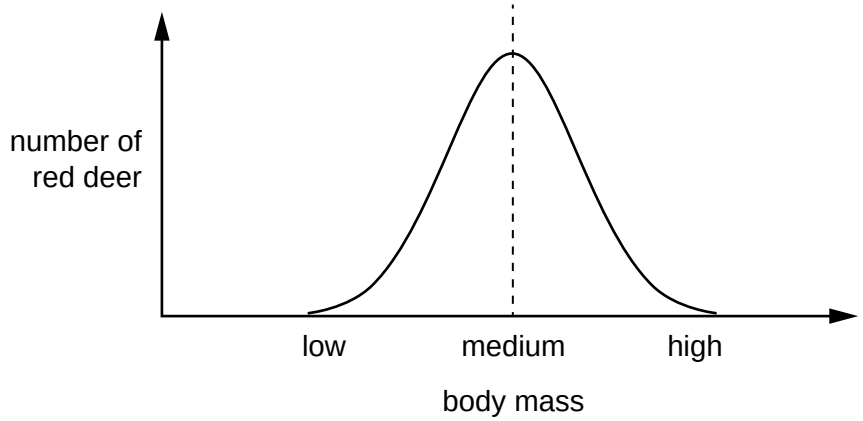

Fig. 7.2

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

(i) Sketch a curve on Fig. 7.3 to show the pattern of variation of body mass in this red deer population after this time.

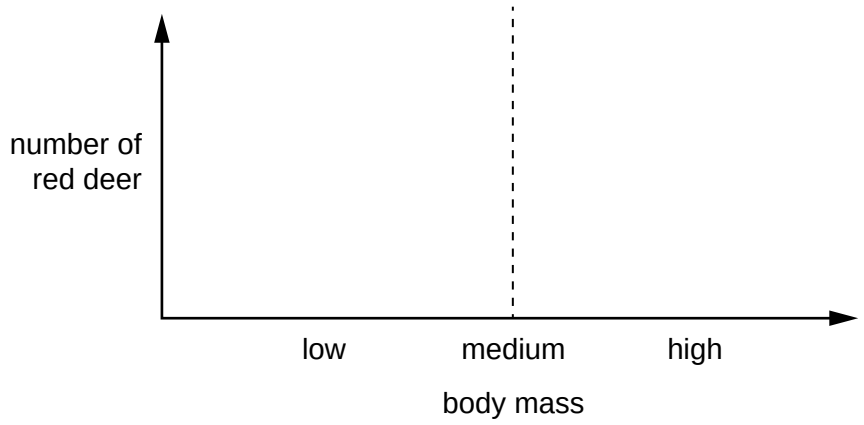

Fig. 7.3

[1]

(ii) Name the type of force of natural selection that is acting on this population.

..... [1]

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

(i) Sketch a curve on Fig. 7.4 to show the pattern of variation of body mass in this red deer population after this time.

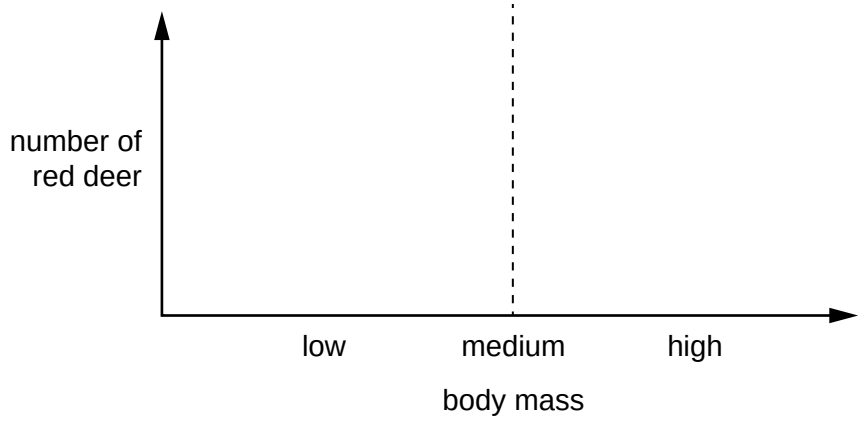

Fig. 7.4

[1]

(ii) Name the type of force of natural selection that is acting on this population.

..... [1]

[Total: 7]

8 **(a)** During a sporting event, an athlete carries out aerobic respiration.

Structures and compounds involved in aerobic respiration are listed, **1** to **10**.

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

Complete Table 8.1 by matching each description 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.

Table 8.1

description	number
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]

(b) Sometimes the muscle cells of an athlete need to carry out respiration in anaerobic conditions.

Explain why the respiration of glucose in anaerobic conditions produces less ATP than in aerobic conditions.

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..... [5]

[Total: 11]

9 The diversity of dung beetle species was investigated at two grassland sites in North America. Dung beetles feed on animal faeces (dung).

The first grassland site was grazed by cattle and the second grassland site was **not** grazed by cattle. The areas of the two grassland sites were the same.

At each grassland site, dung beetles were collected, identified and counted.

(a) The results are shown in Table 9.1.

Table 9.1

dung beetle species	number of dung beetles on grassland grazed by cattle	number of dung beetles on grassland not grazed by cattle
A	4267	6641
B	2005	774
C	353	108
D	218	85
total	6843	7608

(i) Simpson's index of diversity (*D*) for the dung beetles on the grassland site grazed by cattle was calculated as 0.522, using the formula:

$$D = 1 - \left(\sum \left(\frac{n}{N} \right)^2 \right)$$

Key to symbols:
n = number of individuals of each species present in the sample
N = the total number of all individuals of all species present in the sample

Calculate Simpson's index of diversity (*D*) for the dung beetles on the grassland site that was **not** grazed by cattle.

Complete Table 9.2 to show your working.

Write your final answer to **three** decimal places on the dotted line.

Table 9.2

dung beetle species	number of dung beetles on grassland not grazed by cattle	$\frac{n}{N}$	$\left(\frac{n}{N}\right)^2$
A	6641		
B	774		
C	108		
D	85		
total	7608		

Simpson's index of diversity (D) = ... [3]

(ii) Describe what the results in Table 9.1 and **both** figures for Simpson's index of diversity show about the effect of grazing by cattle on the diversity of dung beetles.

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..... [2]

(b) Other species of beetle that do **not** feed on animal dung are found on the grassland sites.

Name **and** describe **one** method for estimating the population size of a species of beetle that does **not** feed on dung in each of the two areas of grassland.

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..... [4]

[Total: 9]

10 Explain genetic control of protein production in a prokaryote using the *lac* operon.

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..... [7]