



Rewarding Learning

ADVANCED
General Certificate of Education
2022

Centre Number

--	--	--	--	--

Candidate Number

--	--	--	--

Biology

Assessment Unit A2 2

assessing

Biochemistry, Genetics and
Evolutionary Trends

MV24

[ABY21]

THURSDAY 16 JUNE, MORNING

Time

2 hours 15 minutes, plus your additional time allowance.

Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write on blank pages.

Complete in black ink only.

Answer **all nine** questions.

Information for Candidates

The total mark for this paper is 100. Section A carries 82 marks. Section B carries 18 marks. Figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

Use accurate scientific terminology in all answers.

You should spend approximately **25 minutes** on Section B.

You are expected to answer Section B in continuous prose.

Quality of written communication will be assessed in Section B.

Statistics Sheets are not required for use with this paper.

Section A

1 (a) The Hardy-Weinberg equation can be used to calculate allele, genotype and phenotype frequencies in a population.

(i) The letter **p** represents the frequency of the dominant allele of a gene in a population. State what **q²** represents.
[1 mark]

(ii) Using **p** and/or **q**, state how the frequency of heterozygotes is represented in a population.
[1 mark]

(iii) Suggest **one** reason why the Hardy-Weinberg equation is **not** applicable to bacterial populations.
[1 mark]

(b) 'Gene pool' is a term associated with population genetics.

Define the term gene pool. [1 mark]

- 2 The photograph below shows a bee (an insect) on a flower.



- (a) (i) Name the phylum to which insects belong. [1 mark]

- (ii) Using the photograph, identify one **visible** feature that is a distinguishing characteristic of this phylum. [1 mark]

(b) Insects are the most successful animals on Earth, both in terms of number of species and number of individuals.

It is estimated that there may be as many as 5×10^6 species of insects, but only (approximately) one million have been discovered and named so far.

(i) Based on these estimates, calculate the number of insect species still to be discovered. [1 mark]

(ii) Suggest **one** reason why so many insect species have yet to be discovered. [1 mark]

The success of insects is mainly due to their basic body plan, an ability to fly and their small size.

(iii) Suggest **one** way in which each of the following has contributed to the success of insects. [2 marks]

Ability to fly _____

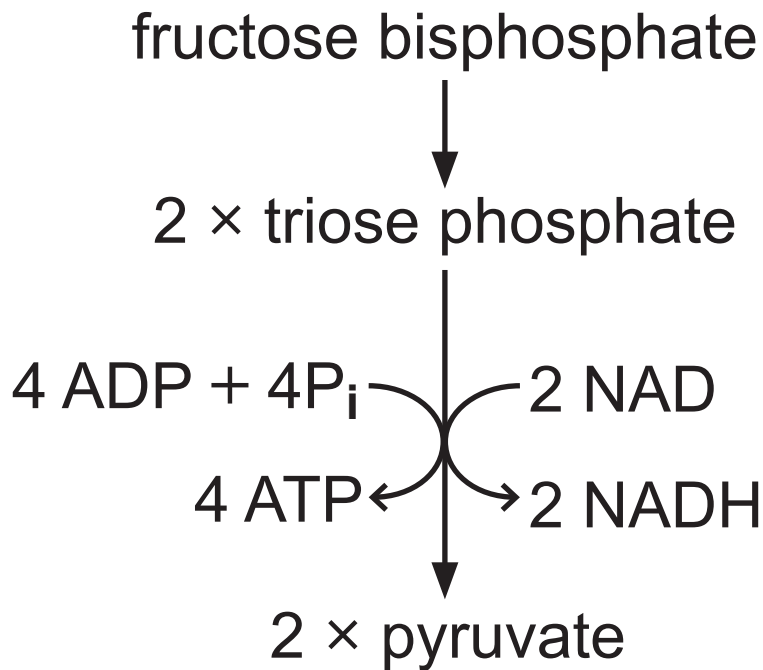
Small size _____

In evolutionary terms, members of the phylum Chordata are regarded as being more advanced than insects.

(c) State **one** characteristic of Chordata which is **not** present in insects.

[1 mark]

- 3 (a)** The diagram below summarises the formation of pyruvate from fructose biphosphate in the biochemistry of respiration.



- (i)** Name the part of the cell where this stage takes place. [1 mark]

- (ii)** State the number of carbon atoms in fructose biphosphate. [1 mark]

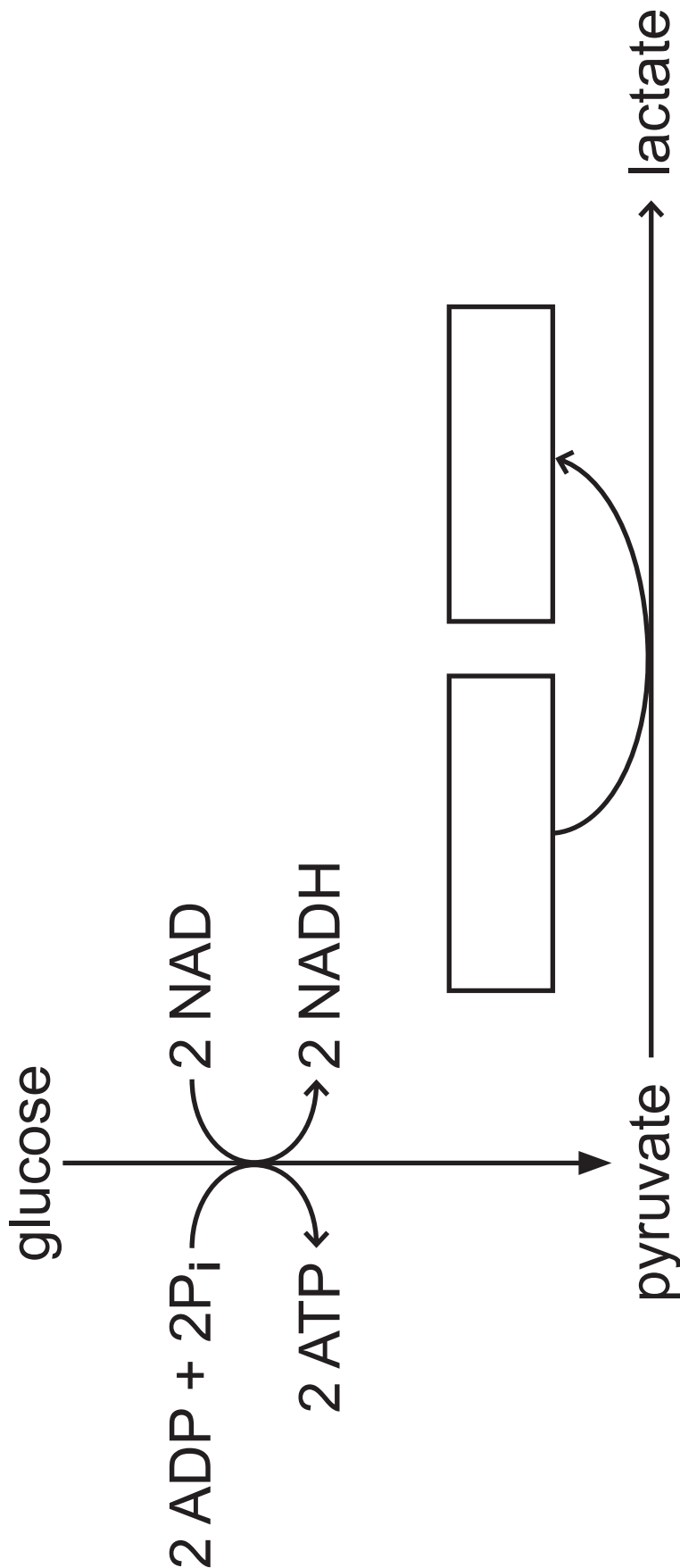
The diagram on page 8 shows that 4 ATP are produced during this stage.

(iv) Using the information provided and your knowledge, explain precisely why there is a net gain of only 2 ATP during the stage shown in the diagram. [1 mark]

Blank Page

(Questions continue overleaf)

(b) The partially completed diagram below summarises the process of anaerobic respiration in animal cells.



- (i) Complete the diagram opposite to show the missing components.
[1 mark]

Anaerobic respiration in animal cells produces lactate, whereas anaerobic respiration in plant cells produces ethanol.

- (ii) Suggest **two** advantages of producing lactate rather than ethanol.
[2 marks]

1. _____

2. _____

(c) Anaerobic respiration in plants produces a respiratory quotient (RQ) greater than 1.

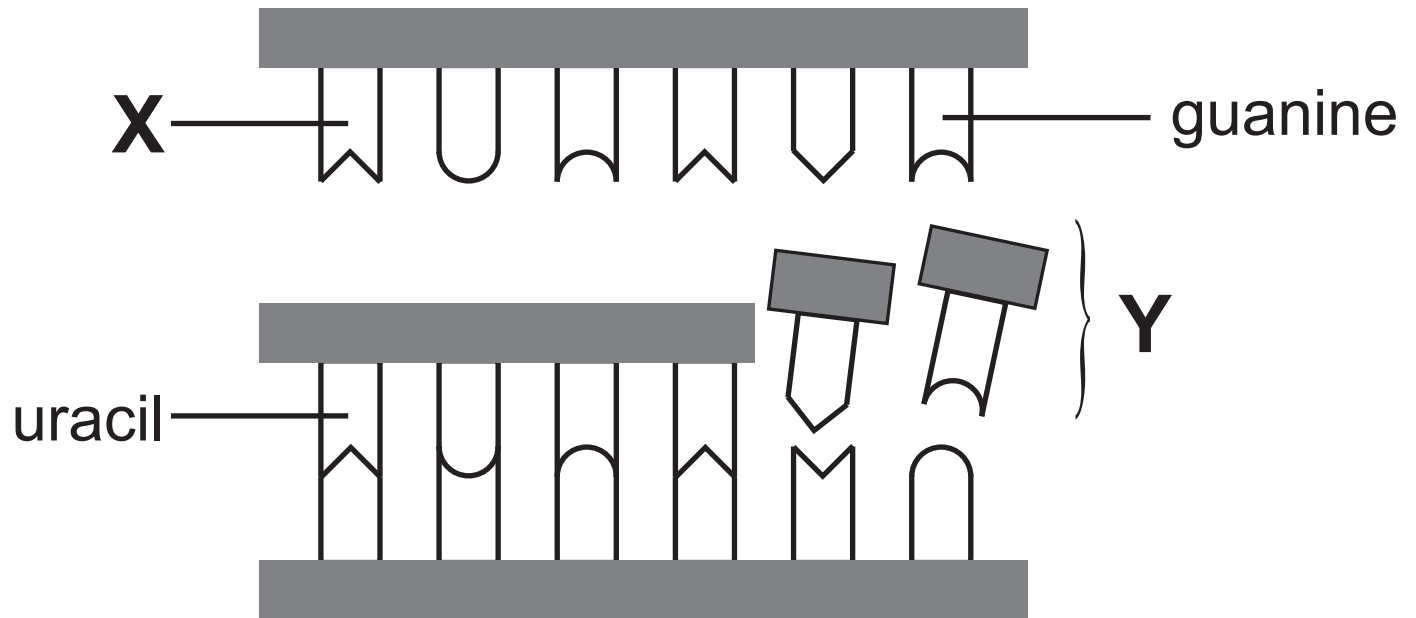
(i) Describe how RQ is calculated.
[1 mark]

(ii) Using your understanding of the stages of respiration in plant cells, explain precisely why anaerobic respiration produces an RQ greater than 1. [3 marks]

Blank Page

(Questions continue overleaf)

- 4 (a) The diagram below represents a short section within a chromosome during the process of transcription.



- (i) Identify base **X** and component **Y**.
[2 marks]

X _____

Y _____

(ii) Using the diagram, identify **two** pieces of evidence which show that transcription, rather than DNA replication, is taking place.

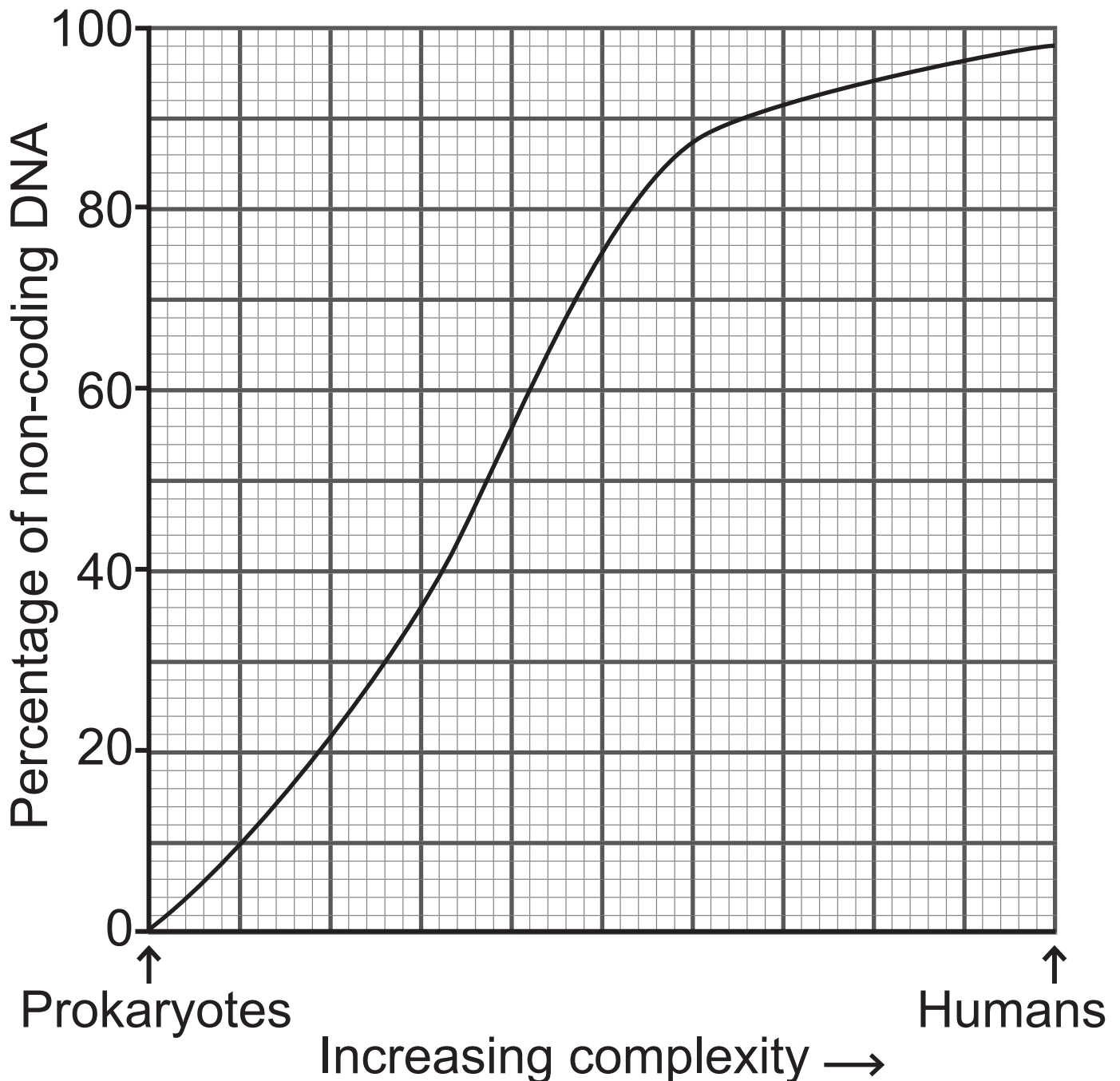
[2 marks]

1. _____

2. _____

(iii) State the role of RNA polymerase in transcription. [1 mark]

(b) The graph below summarises how the percentage of non-coding DNA in cells changes as organisms become more complex.



(i) Using the graph, determine the percentage of **coding** DNA in humans. [1 mark]

_____ %

(ii) Identify and explain evidence from the graph which confirms that prokaryotes do **not** have introns. [2 marks]

(iii) Chromosome centromeres are an example of non-coding DNA. State the function of centromeres. [1 mark]

(c) Cancer refers to a range of diseases in which some cells divide uncontrollably to the extent that they can form a large mass of undifferentiated tissue (tumour).

(i) Suggest what the term 'undifferentiated tissue' means in this context. [1 mark]

Methylation is an epigenetic change which involves methyl groups being added to DNA bases.

(ii) Name the base involved in DNA methylation. [1 mark]

Excessive methylation of mitosis-suppressing genes can be a factor leading to cancer.

(iii) Using your understanding of epigenetics, explain how this can occur. [2 marks]

5 (a) Young calves, as with other mammals, feed almost exclusively on their mother's milk. During this developmental stage they produce enzymes to coagulate (clot) the milk they drink. This slows the movement of milk through the digestive system.

(i) Suggest **one** advantage of slowing the movement of milk through the gut.
[1 mark]

The enzymes involved in clotting milk, collectively known as rennet, are used in cheese-making.

Rennet was traditionally extracted from the stomach lining of very young calves, a process which obtained a small amount of rennet from each calf.

More recently, chymosin (the most effective enzyme in rennet) has been produced using genetically engineered microorganisms (GEMs). This source of chymosin is now used in the production of up to 70% of cheese products.

(ii) Using the information provided, suggest **two** reasons why genetically engineered enzymes are increasingly being used in the cheese industry.

[2 marks]

1. _____

2. _____

(iii) Using your understanding of gene technology, briefly outline how bacteria can be genetically modified to produce chymosin. [3 marks]

(b) Microsatellite repeat sequences (MRSs) are sections of DNA where a small sequence of bases is repeated many times. The number of repeats in a particular MRS varies in individuals and this difference is the basis of genetic fingerprinting.

In genetic fingerprinting, the bars seen on the electrophoresis gel represent MRS fragments and as these differ between individuals, the appearance of the 'fingerprint' on the gel will also vary between individuals.

When isolating MRSs from DNA, it is important that restriction endonucleases accurately cut the DNA at the start and end of each MRS.

(i) Explain why a detailed knowledge of the organism's genome is necessary for this purpose. [1 mark]

(ii) In a genetic fingerprint, a number of different MRSs (e.g. 10–15) from different parts of the genome are used. Suggest why it is important to use more than one MRS for this purpose. [1 mark]

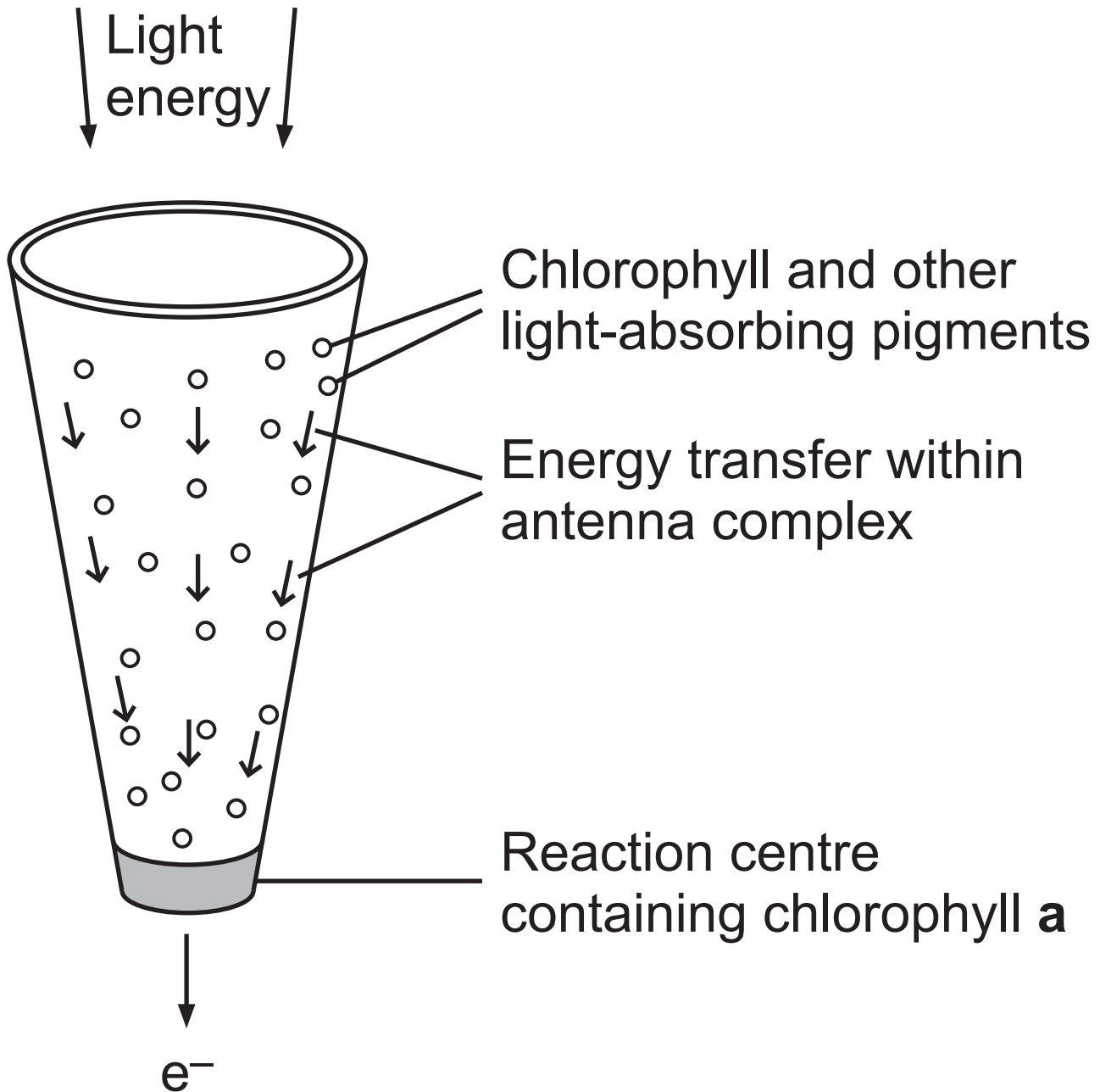
(iii) The Polymerase Chain Reaction (PCR) is normally used to produce the DNA used in genetic fingerprinting. State why this would be necessary. [1 mark]

(iv) Genetic fingerprinting is frequently used in criminal investigations. State **one** other use of genetic fingerprinting. [1 mark]

6 Photosynthesis takes place in plant chloroplasts. It involves a light-dependent reaction (including light harvesting) and a light-independent reaction.

(a) Define the term 'photosynthesis action spectrum'. [1 mark]

(b) The diagram below represents an antenna complex in a chloroplast. When enough light energy is absorbed, electrons are emitted from chlorophyll a.



(i) Explain the advantage of the presence of a range of different light-absorbing pigments in the antenna complex. [2 marks]

(ii) Describe the fate of electrons emitted by chlorophyll **a** in a PSI antenna complex. [2 marks]

Electrons emitted from chlorophyll a molecules are replaced.

(iii) State the source of the electrons which replace those emitted from PSI.
[1 mark]

(c) The compensation point of a plant is affected by rates of photosynthesis and respiration.

(i) Define the term 'compensation point'.
[1 mark]

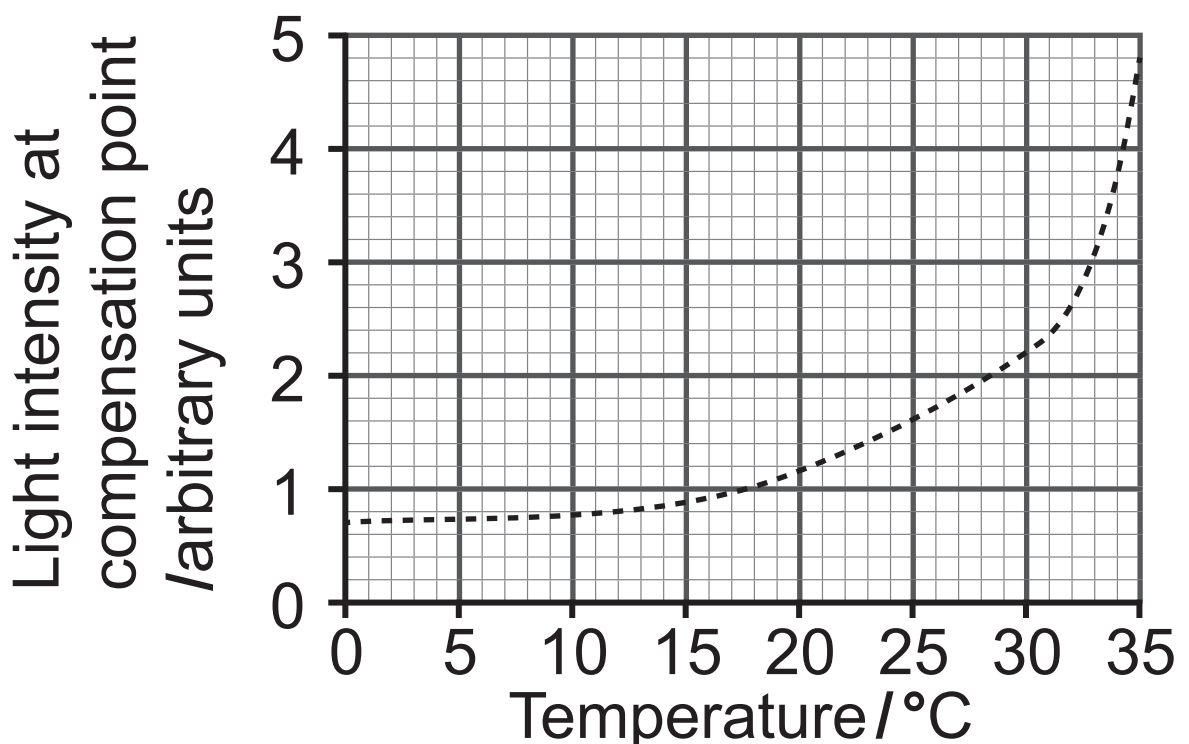
Blank Page

(Questions continue overleaf)

The rate of photosynthesis can be affected by changes in light, temperature and CO₂ concentration.

The rate of respiration is affected by changes in temperature (but not changes in light or CO₂).

The graph below shows how light intensity at the compensation point varies with changes in temperature in beech trees (*Fagus sylvatica*).



7 (a) The alleles of many genes can be described as being dominant or recessive.

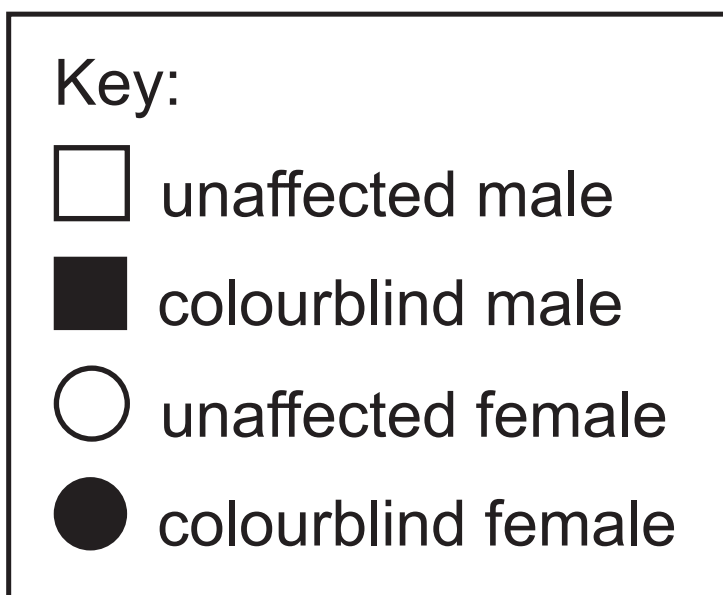
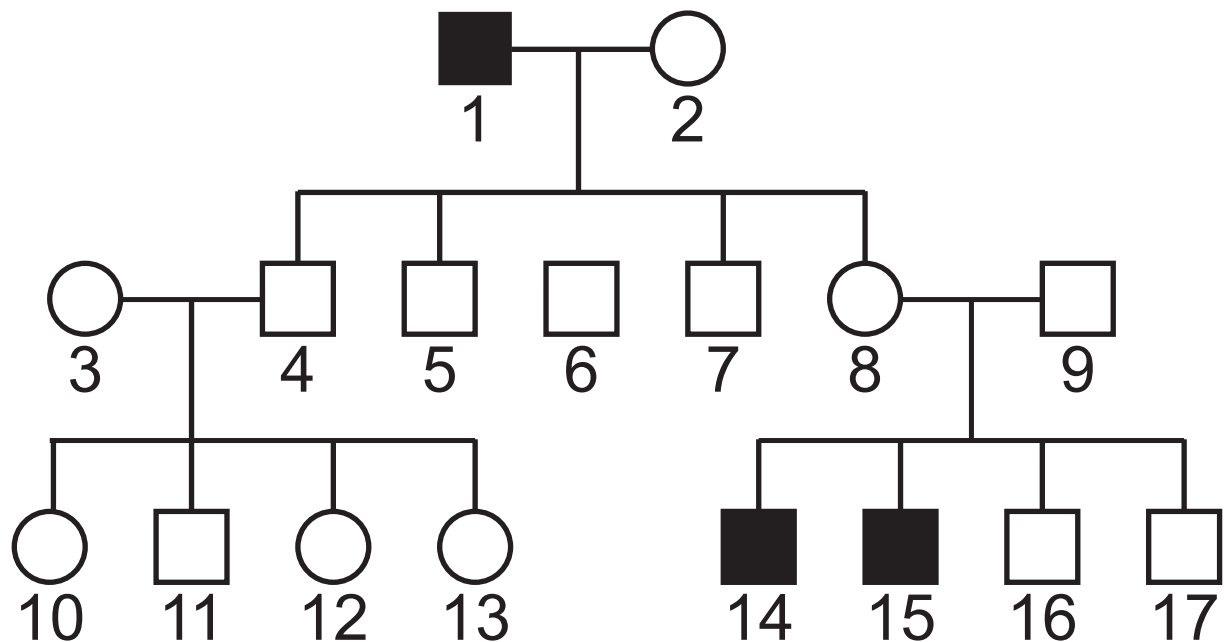
In this context, describe what is meant by the term 'recessive'. [1 mark]

(b) The inheritance of traits in humans can be described as:

- autosomal dominant
- autosomal recessive
- sex-linked dominant
- sex-linked recessive

Analysis of pedigree diagrams can allow the type of inheritance to be determined.

Red-green colour blindness is a human trait where affected individuals find it difficult to distinguish between shades of red and green, due to a gene mutation. The inheritance of red-green colour blindness in a family group is shown in the pedigree diagram below.



(i) Identify the probable genotypes of individuals **1**, **4** and **8**. [3 marks]
(In your answer you should only choose symbols from the list B, b, X^B, X^b or Y.)

1 _____

4 _____

8 _____

(ii) Identify the type of inheritance shown by red-green colour blindness from those listed in the bullet points at **(b)**. [1 mark]

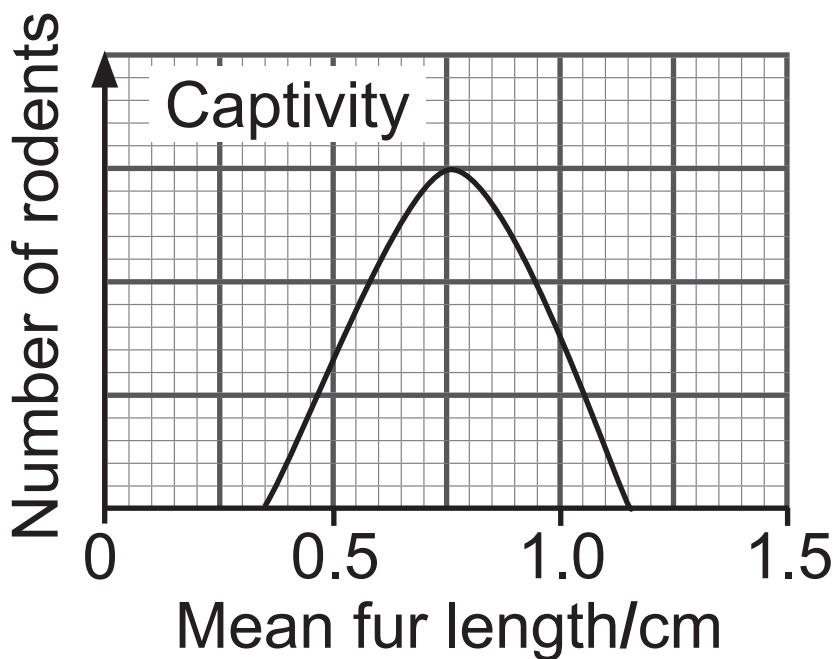
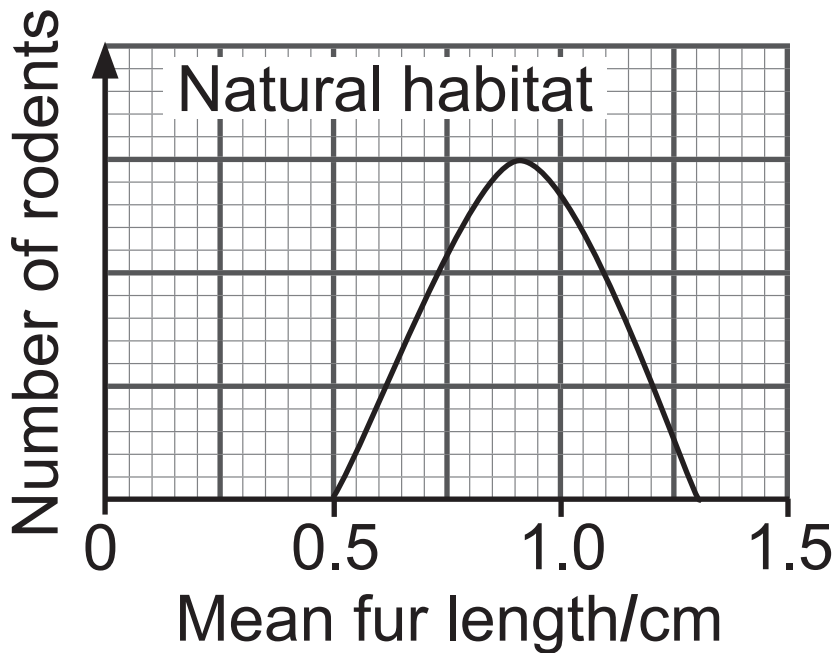
(c) Huntington's disease and Marfan Syndrome are each caused by the presence of a dominant allele. The genes for Huntington's disease and Marfan Syndrome are on separate autosomes.

Two individuals, one heterozygous for both genes and the other heterozygous for Huntington's disease but not carrying the Marfan allele, had a child.

Using the symbols, H, h (Huntington's disease) and R, r (Marfan Syndrome), complete a genetic diagram to determine the probability that they have a child who is not affected by either condition.

[4 marks]

(d) Mean fur length in two populations of the same rodent species is shown in the graphs below. One population lives in the wild in its natural habitat, while the other population lives in captivity.



(i) Describe how the data suggests that fur length in this species is an example of polygenic inheritance. [1 mark]

(ii) State the evidence which suggests that environment is a factor in determining fur length. [1 mark]

(iii) Suggest a possible explanation for your answer to **(ii)**. [1 mark]

8 Ferns and flowering plants (angiosperms) are regarded as being more highly adapted than mosses in terms of their ability to survive in drier habitats.

One adaptation of ferns and flowering plants is the presence of vascular tissue.

(a) (i) Suggest **one** way in which having vascular tissue is an adaptation to a terrestrial habitat. [1 mark]

(ii) Apart from presence of vascular tissue, state **two** features found in both ferns and flowering plants which are adaptations to a terrestrial habitat. [2 marks]

1. _____

2. _____

(b) Mature xylem vessels do not possess end walls or cellular contents and consequently are non-living. These adaptations are necessary for xylem vessels to operate as efficient water transport channels throughout the plant.

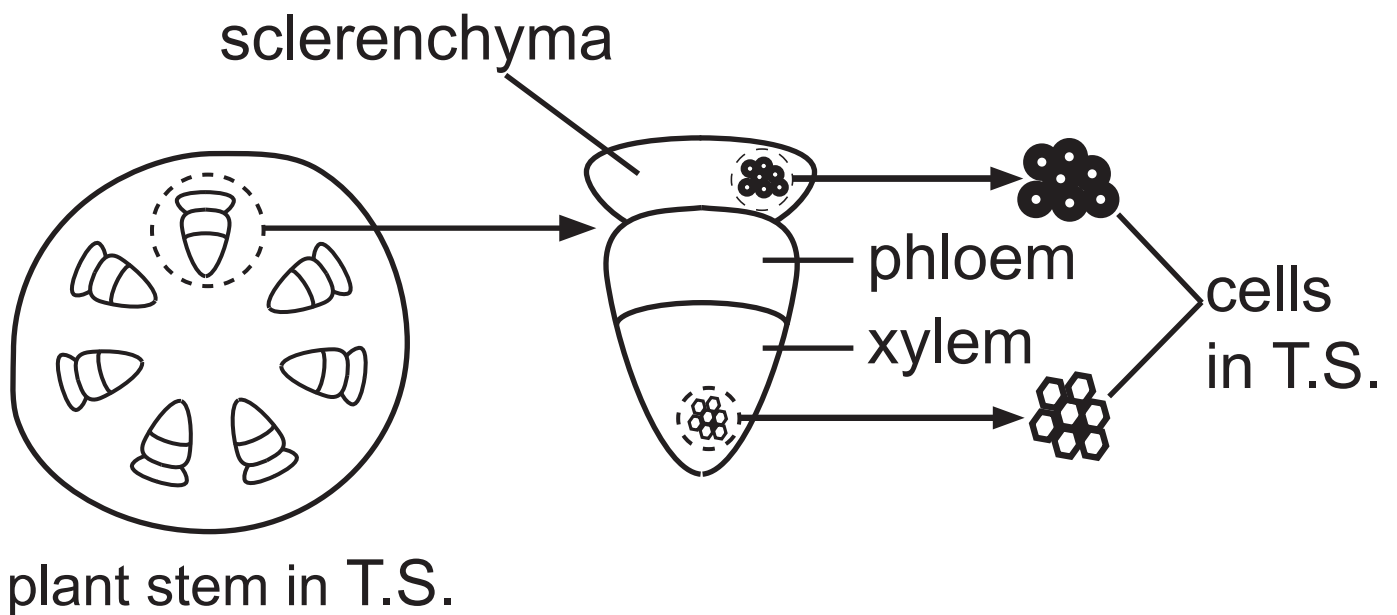
Early in their development, xylem vessels grow and lignin is deposited in their side walls. Once the walls have been lignified, the vacuoles burst and release hydrolytic enzymes. These enzymes break down the cell contents, leaving only the thickened side walls.

(i) Name another cell organelle which releases hydrolytic enzymes to destroy damaged cells. [1 mark]

Oxygen usage in a number of xylem vessels in a plant was monitored over a 40-day period after vessel formation. The results are shown in the table below.

Day	Oxygen usage/ arbitrary units
5	11
10	18
15	25
20	32
25	46
30	47
35	4
40	0

(c) The diagram below represents a transverse section (T.S.) through part of the stem of a flowering plant. In this species, a tissue called sclerenchyma is found immediately outside the vascular bundles of stems. Like xylem vessels, sclerenchyma has cell walls which are thickened with lignin and the cells are dead at maturity with no internal contents.



(i) Sclerenchyma cells and xylem vessels are different shapes in transverse section. Using the diagram, identify **one** other way in which sclerenchyma cells differ from xylem vessels. [1 mark]

(ii) What does this difference suggest about the function of sclerenchyma? Explain your answer. [2 marks]

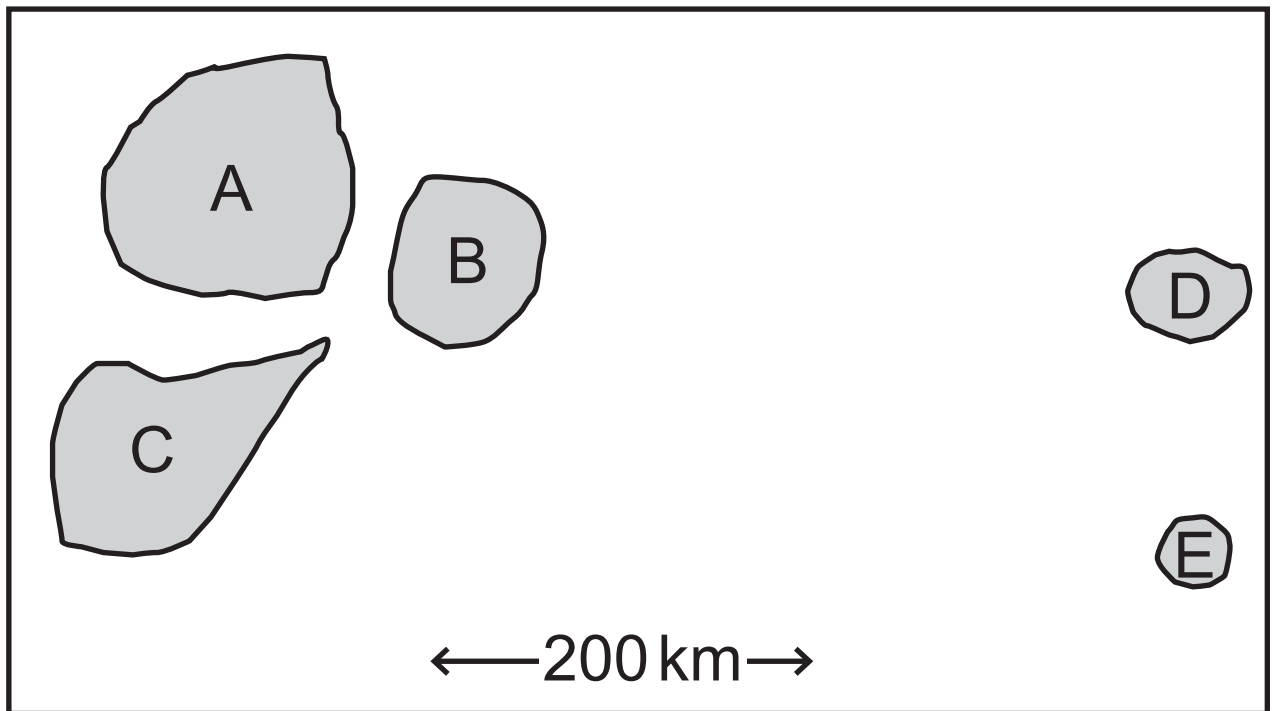
Section B

Quality of written communication will be assessed in this section.

9 Variation, fitness, selection and evolutionary change are key terms in explaining how species adapt and change over time. Evolutionary change can be particularly rapid in island populations.

(a) Outline the main causes of variation in living organisms. [6 marks]

The diagram opposite represents a small group of volcanic islands in the central Pacific Ocean, isolated from other land masses. In general, larger islands have a wider range of habitat types than smaller islands. The table opposite shows some information about each of the islands.



Island	When formed/ million years ago	Number of species
A	12	202
B	12	150
C	12	190
D	7	47
E	7	35

(b) With reference to variation, fitness and selection, describe and explain how evolutionary change occurs over time and account for the differences in species number across this island group. [12 marks]

SOURCES

Q2 © James Napier

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total Marks	

Examiner Number

Permission to reproduce all copyright material has been applied for.
In some cases, efforts to contact copyright holders may have been unsuccessful and CCEA will be happy to rectify any omissions of acknowledgement in future if notified.