Rewarding Learning

ADVANCED
General Certificate of Education
2022

Centre Number

Candidate Number

Biology

Assessment Unit A2 2
assessing
Biochemistry, Genetics and Evolutionary Trends

[ABY21]

ABY21

THURSDAY 16 JUNE, MORNING

TIME

2 hours 15 minutes.

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 outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**
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 down the right-hand side of pages 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.

13490

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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 $\mathbf{q^2}$ represents.

_____

_____ [1]

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

_____ [1]

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

_____

_____ [1]

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

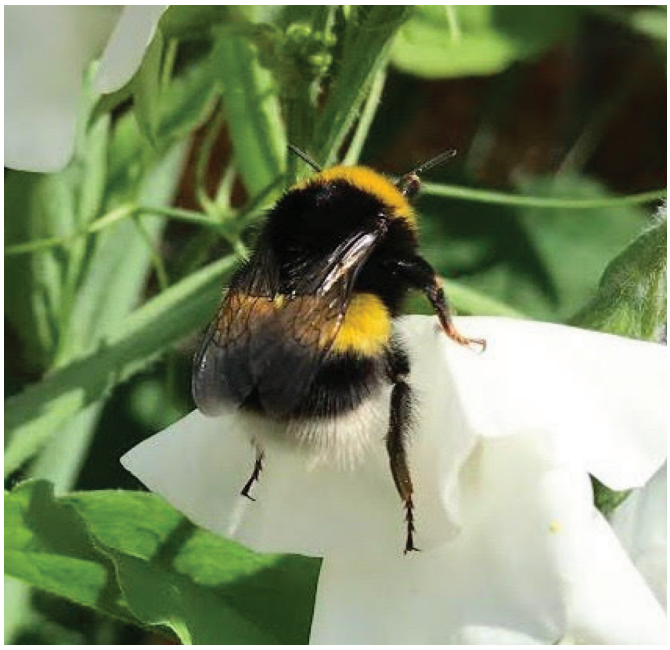
_____

_____

_____ [1]

[Turn over

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



© James Napier

(a) (i) Name the phylum to which insects belong.

_____ [1]

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

_____ [1]

(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]

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

_____

_____ [1]

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.

Ability to fly _____

_____

Small size _____

_____ [2]

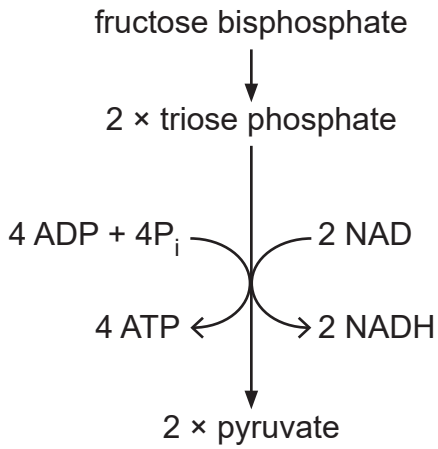
In evolutionary terms, members of the phylum Chordata are regarded as being more advanced than insects.

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

_____ [1]

[Turn over

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



(i) Name the part of the cell where this stage takes place.

_____ [1]

(ii) State the number of carbon atoms in fructose bisphosphate.

_____ [1]

(iii) Describe how the NADH produced during this stage subsequently leads to the production of ATP.

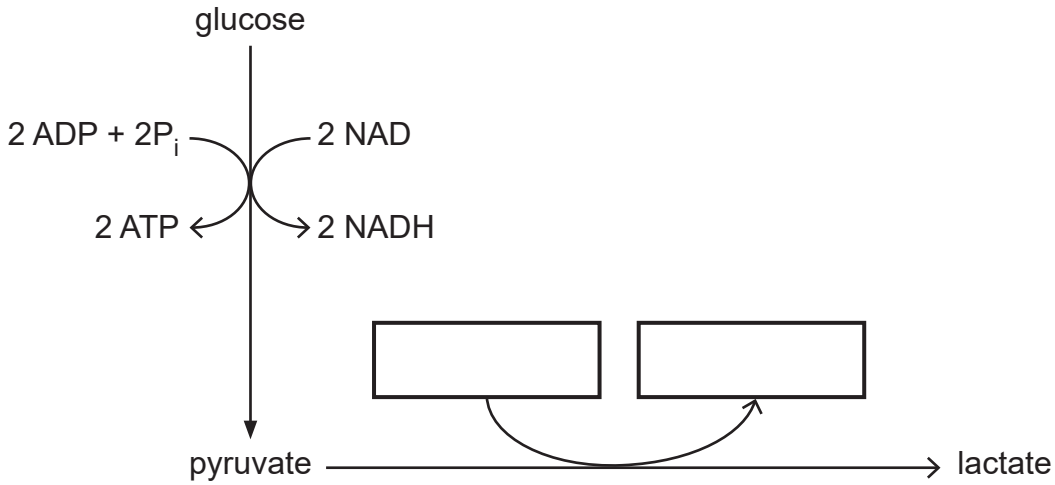
[4]

The diagram opposite 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]

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



(i) Complete the diagram above to show the missing components. [1]

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.

1. _____

_____

2. _____

_____ [2]

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

(i) Describe how RQ is calculated.

_____

_____ [1]

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

_____

_____

_____

_____

_____

_____

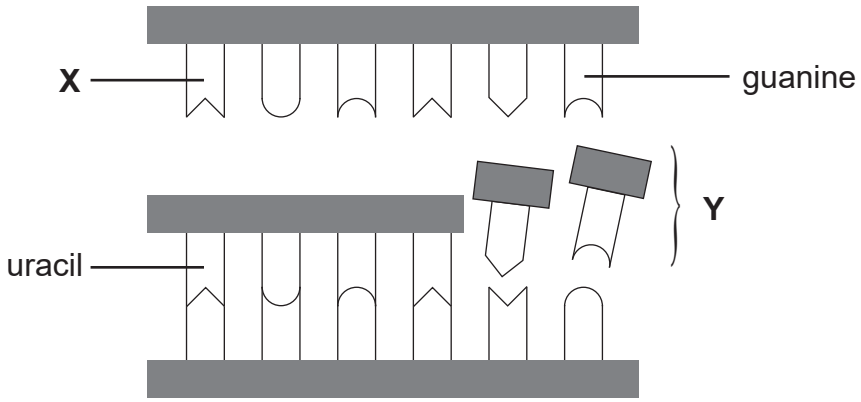
_____

_____

_____ [3]

[Turn over

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



(i) Identify base **X** and component **Y**.

X _____

Y _____ [2]

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

1. _____

_____

2. _____

_____ [2]

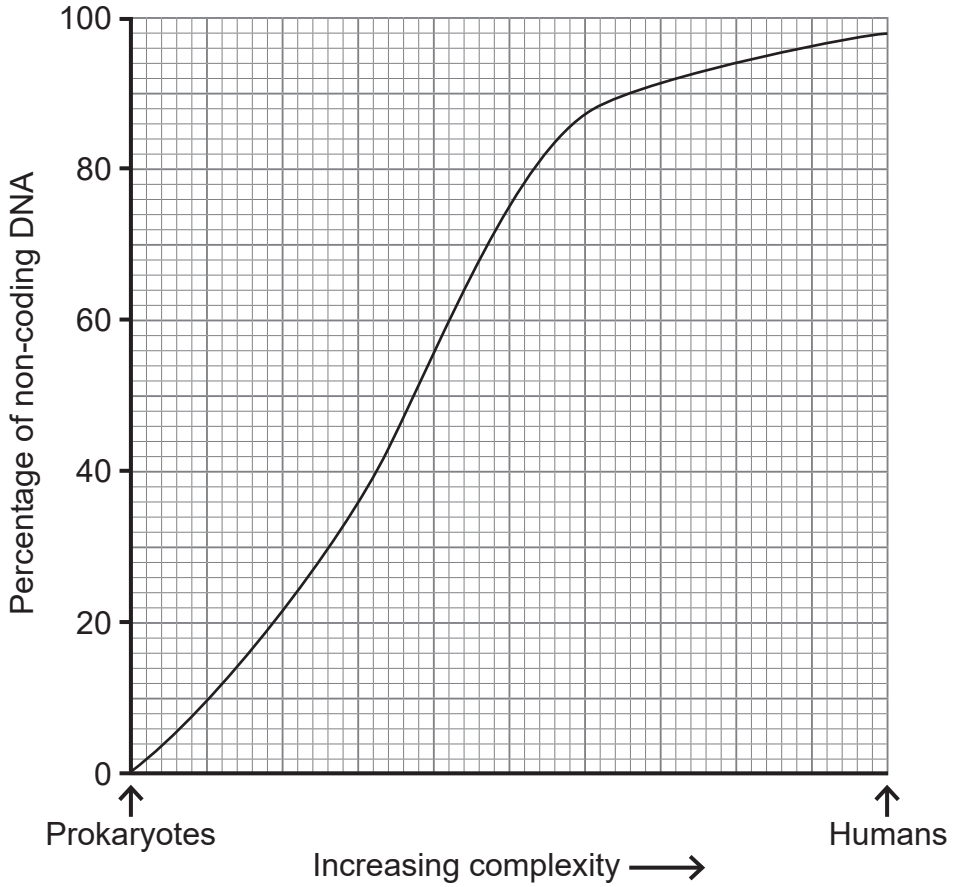
(iii) State the role of RNA polymerase in transcription.

_____

_____

_____ [1]

(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]

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

_____

_____

_____

_____

_____ [2]

[Turn over

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

_____

_____

_____ [1]

(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]

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

(ii) Name the base involved in DNA methylation.

_____ [1]

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]

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]

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.

1. _____

_____

2. _____

_____ [2]

[Turn over

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

_____

_____

_____

_____

_____

_____

_____

_____

_____ [3]

(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]

(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]

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

_____

_____

_____ [1]

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

_____ [1]

[Turn over

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

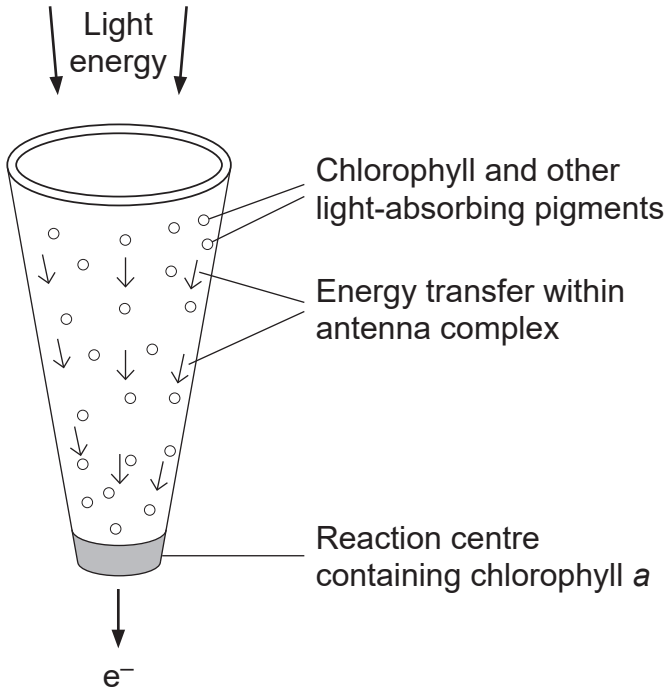
(a) Define the term 'photosynthesis action spectrum'.

_____

_____

_____ [1]

(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]

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

_____

_____

_____

_____ [2]

Electrons emitted from chlorophyll *a* molecules are replaced.

(iii) State the source of the electrons which replace those emitted from PSI.

_____

_____ [1]

[Turn over

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

(i) Define the term 'compensation point'.

_____

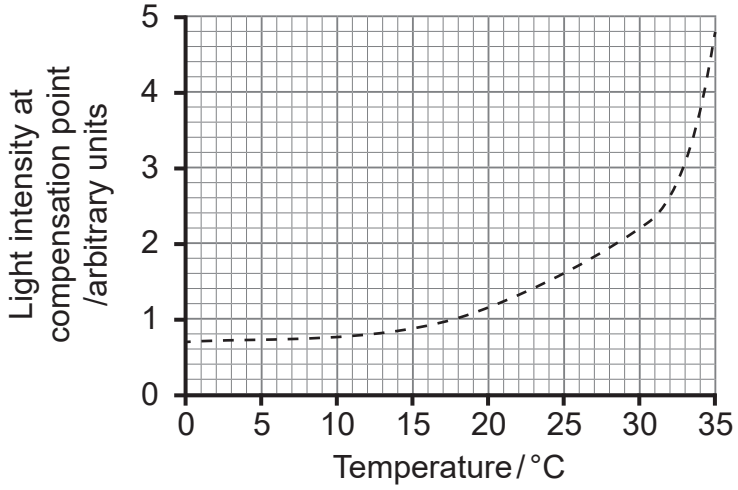
_____

_____ [1]

The rate of photosynthesis can be affected by changes in light, temperature and CO_2 concentration.

The rate of respiration is affected by changes in temperature (but not changes in light or CO_2).

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



(ii) Describe and explain the results shown.

[4]

[Turn over

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'.

_____

_____

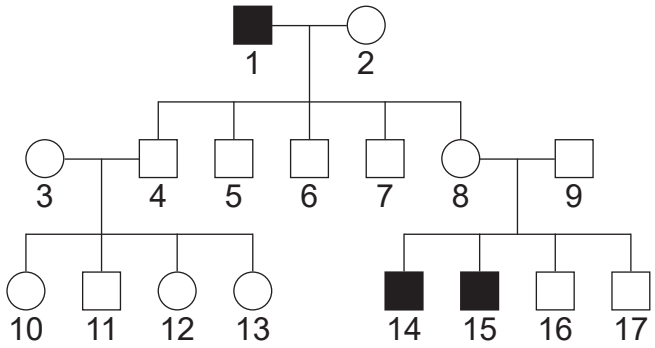
_____ [1]

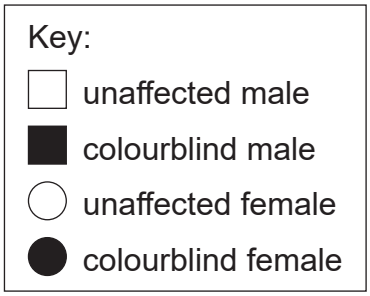
(b) The inheritance of traits in humans can be described as:

- 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**.
(In your answer you should only choose symbols from the list B, b, X^B, X^b or Y.)

1 _____

4 _____

8 _____ [3]

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

_____ [1]

(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.

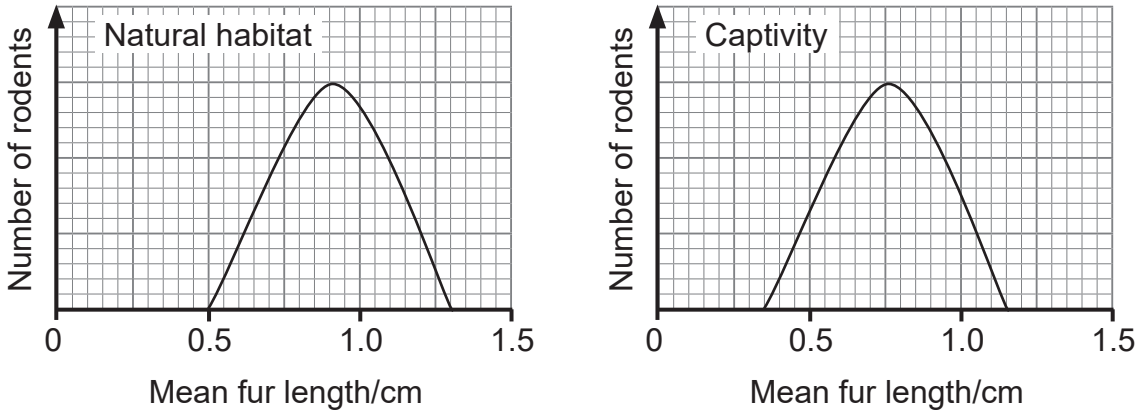
Two individuals, one heterozygous for both genes and the other heterozygous for Huntington's disease but not carrying the Marfan allele, had a child.

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]

[Turn over

(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]

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

_____

_____

_____ [1]

(iii) Suggest a possible explanation for your answer to **(ii)**.

_____

_____

_____ [1]

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]

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

1. _____

_____

2. _____

_____ [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]

[Turn over

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

(ii) Using all the information provided, describe and explain the results shown.

_____

_____

_____

_____

_____

_____

_____

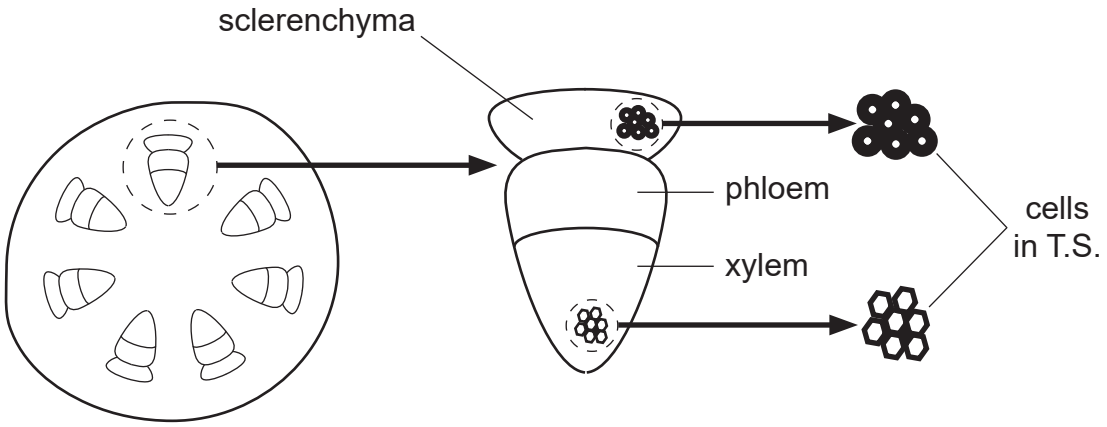
_____

_____

_____

_____ [4]

(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]

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

_____

_____

_____

_____

_____ [2]

[Turn over

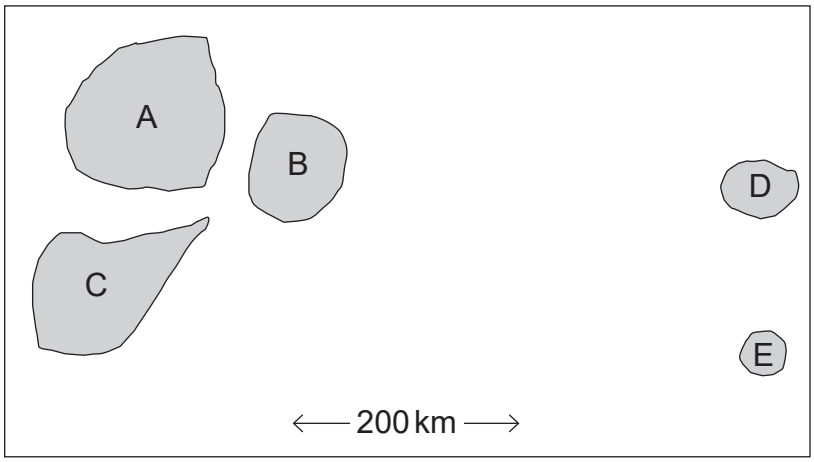
Section B

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]

The diagram below 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 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]

(a) Outline the main causes of variation in living organisms.

[Turn over

(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.

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For Examiner's use only	
Question Number	**Marks**
1	
2	
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Total Marks	

Examiner Number