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EDEXCEL A LEVEL BIOLOGY B: QUESTIONS BY TOPIC

Classification and Biodiversity (3)

A Level Biology B Topic 3

46 questions · 505 marks · Mark schemes included

Pearson Edexcel AS (8BI0) and A Level (9BI0) Biology B, June 2016 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.
Click any heading or question row below to jump straight to it.
On every question page, click ANSWER in the top-right corner to jump to its mark scheme.
Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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3(a)	**CLASSIFICATION AND THE THREE DOMAINS**			11 questions · 94 marks	**4**
1.	**Q1**	*also Topic 2*	A Level Paper 3 June 2025	6	**5**
2.	**Q1**		AS Paper 2 November 2021	7	**7**
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QUESTIONS

46 questions · 505 marks · grouped by sub-topic, lowest tariff first

SUB-TOPIC 3(a)

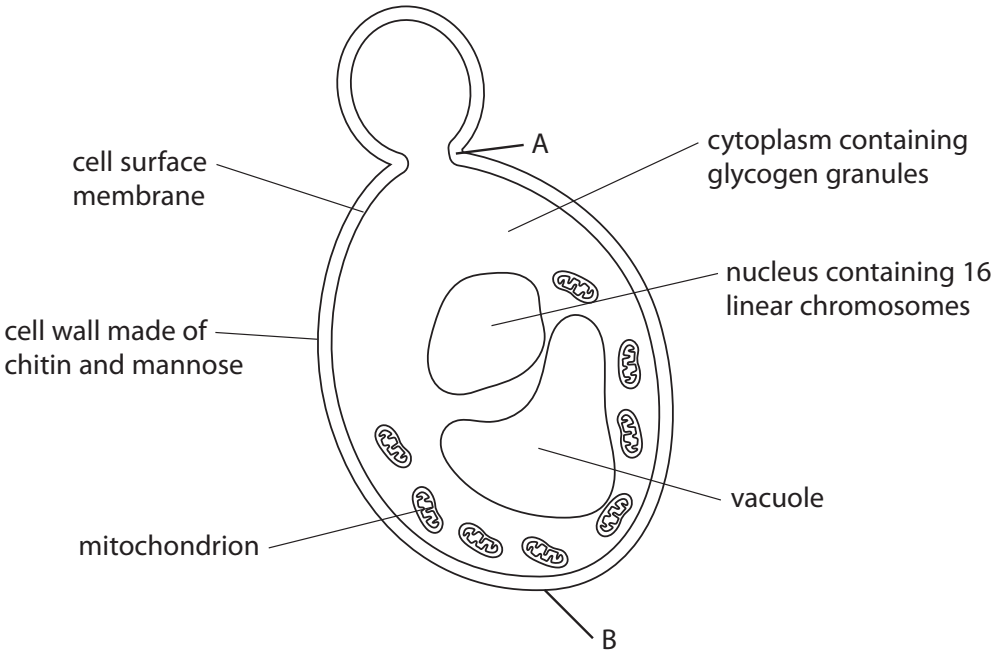
CLASSIFICATION AND THE THREE DOMAINS

11 questions in this sub-topic · 94 marks · lowest tariff first

Write your answers in the spaces provided.

1 *Saccharomyces cerevisiae* (yeast) is a single-celled organism widely used in brewing and baking.

The diagram shows a drawing of a yeast cell, as seen using an electron microscope.



(a) The actual size of the cell measured from point A to point B is 6 μm.

Calculate the magnification of this yeast cell.

Give your answer to the **nearest whole number**.

(2)

Answer .....

(b) Draw this yeast cell as it would be seen using a light microscope at high magnification.

Labels are not required.

(2)

(c) The information in the diagram can be used to classify yeast.

(i) State why yeast is classified as eukaryotic not prokaryotic.

(1)

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(ii) State why yeast is not classified as a plant.

(1)

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(Total for Question 1 = 6 marks)

1 Biologists classify organisms based on characteristics and on evolutionary relationships.

(a) (i) Which of these groups contains the greatest variety of organisms?

(1)

- ☒ **A** genus
- ☒ **B** kingdom
- ☒ **C** phylum
- ☒ **D** species

(ii) Closely-related genera are grouped together in a

(1)

- ☒ **A** class
- ☒ **B** domain
- ☒ **C** family
- ☒ **D** order

(iii) Which of these is a kingdom?

(1)

- ☒ **A** Archaea
- ☒ **B** Bacteria
- ☒ **C** Eukarya
- ☒ **D** Protista

(b) (i) Explain the evidence that led to the three-domain model of classification replacing the five-kingdom model.

(3)

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(ii) Give a method that a scientist, with a new theory based upon experimental results, could use to share this with others in the scientific community.

(1)

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(Total for Question 1 = 7 marks)

2 Living organisms are divided into three domains: Archaea, Bacteria and Eukaryota.

(a) The table shows some characteristics of organisms in the domain Archaea.

Characteristic	Organisms in the domain Archaea
membrane-enclosed nucleus	absent
peptidoglycan in cell wall	absent
ribosomes	70S

Explain why these organisms have **not** been classified in either of the other two domains.

(2)

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(b) Some Archaea have the enzyme adenylate kinase (AK).

This enzyme is similar to AK enzymes found in humans.

There are two types of this enzyme in humans, AK1 and AK3.

The table gives some information about these two enzymes.

Enzyme	Location in the cell	Substrate	Role of enzyme
AK1	cytoplasm	adenosine triphosphate (ATP)	transfers phosphate
AK3	mitochondria	guanosine triphosphate (GTP)	transfers phosphate

(i) The tertiary structures of AK1 and AK3 are very similar but not identical.

Analyse the information to deduce why there are two AK enzymes.

(3)

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(ii) Some types of Archaea have only one type of AK enzyme.

This enzyme can catalyse both the reactions shown in the table.

The tertiary structure of this enzyme is different from AK1 and AK3.

Explain why Archaea have a different type of AK enzyme.

(2)

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2 Minke whales, killer whales and dolphins are all cetaceans.

These animals are different species that all belong to the order Cetacea.

(a) The five-kingdom model of classification is hierarchical.

Part of this hierarchy is: kingdom

phylum

class

family

genus

Where in this hierarchy should the order Cetacea appear?

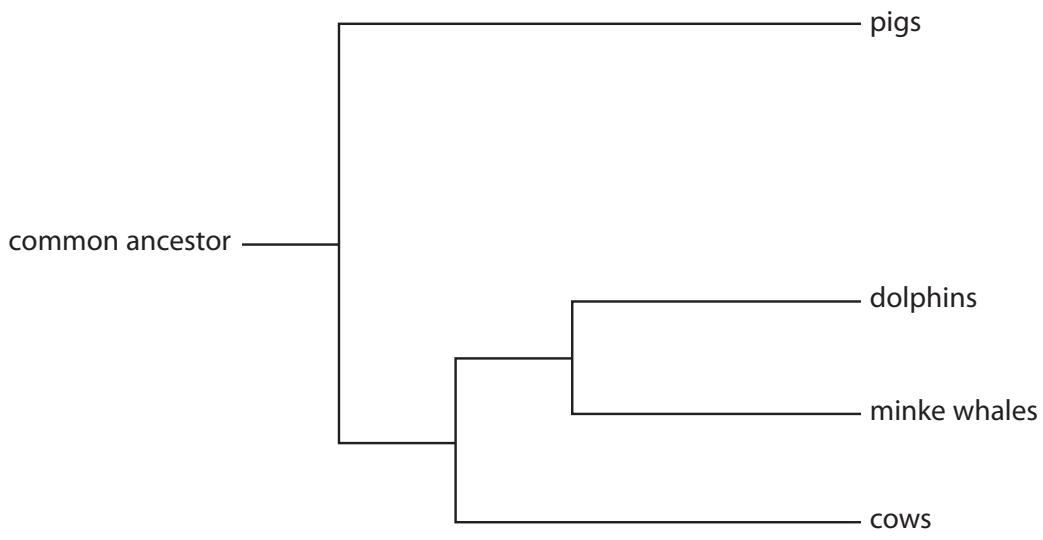
(1)

- ☒ **A** between kingdom and phylum
- ☒ **B** between phylum and class
- ☒ **C** between class and family
- ☒ **D** between family and genus

(b) Cetaceans evolved between 55 and 60 million years ago.

Their closest living relatives are thought to be pigs and cows.

The diagram shows the evolutionary relationship between minke whales, dolphins, pigs and cows.



Analyse the diagram to explain the evolutionary relationship between these four animals.
(3)

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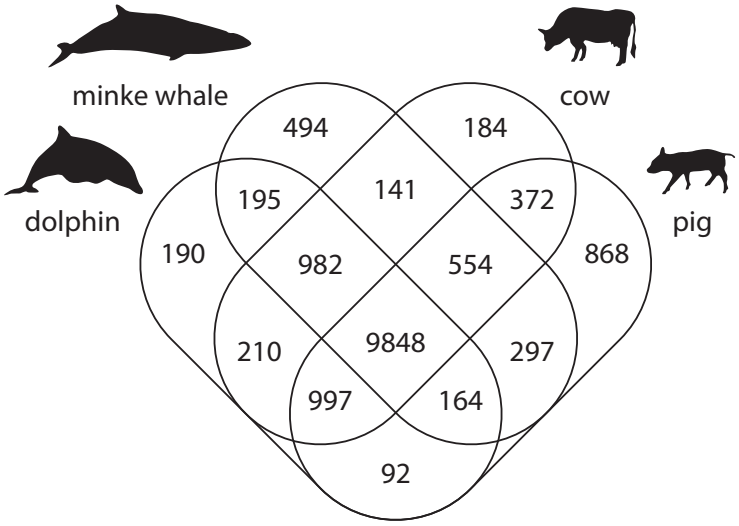
(c) The Venn diagram shows unique and shared gene families in the genomes of minke whales, dolphins, pigs and cows.



Calculate the percentage of a dolphin's gene families that are shared with the minke whale.
(2)

Answer .....%

(d) A wholphin is an extremely rare hybrid animal born from the mating of a female dolphin and a male killer whale.

Kekaimalu was a wholphin born in the United States in 1985. Kekaimalu was mated with a dolphin and on three occasions gave birth to live offspring.

Explain how this case study illustrates the limitations of the definition of a species.

(2)

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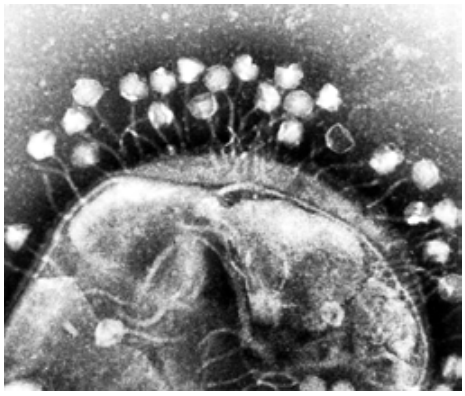
4 The photograph shows part of a bacterial cell surrounded by viruses, as seen using an electron microscope.



(a) (i) Which of these structures would be present in a bacterial cell but absent in a palisade mesophyll cell?

(1)

☒ **A** cellulose cell wall and nucleoid

☒ **B** cellulose cell wall and nucleolus

☒ **C** peptidoglycan cell wall and nucleoid

☒ **D** peptidoglycan cell wall and nucleolus

(ii) Which virus contains DNA?

(1)

☒ **A** Ebola

☒ **B** HIV

☒ **C** λ (lambda) phage

☒ **D** tobacco mosaic

(iii) Explain why an electron microscope, rather than a light microscope, was used to produce this photograph.

(2)

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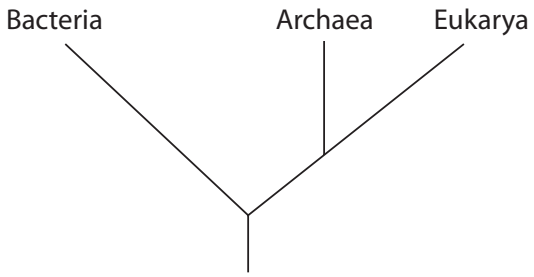
(b) The diagram shows the three-domain model of classification as suggested by Carl Woese.



This model was based on the comparison of many different characteristics.

Some of the characteristics used by Woese are shown in the table.

Characteristic	Archaea	Bacteria	Eukarya
Membrane lipids	branched carbon chains attached to glycerol by **ether** linkage	straight carbon chains attached to glycerol by **ester** linkage	straight carbon chains attached to glycerol by **ester** linkage
First amino acid in protein synthesis	methionine	formylmethionine	methionine
Antibiotic sensitivity	no	yes	no
rRNA loop sequence	absent	present	absent
Ribosome size	70 S	70 S	80 S

(i) Analyse the information to explain the evidence for the three-domain model of classification.

(3)

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(ii) Many scientists agree with this three-domain model.

State how these scientists would have reached agreement about this model.

(1)

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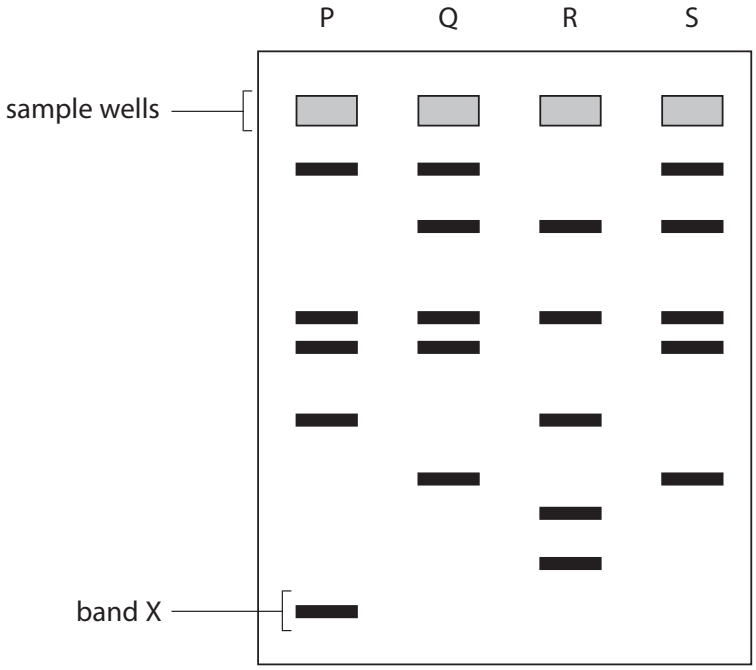
(Total for Question 4 = 8 marks)

3 Gel electrophoresis is a method used to analyse DNA fragments from different organisms.

(a) The diagram shows the results of gel electrophoresis of DNA samples from four organisms: P, Q, R and S.



What is shown by the band labelled X?

(1)

☒ **A** largest fragment of DNA that travelled the fastest

☒ **B** largest fragment of DNA that travelled the slowest

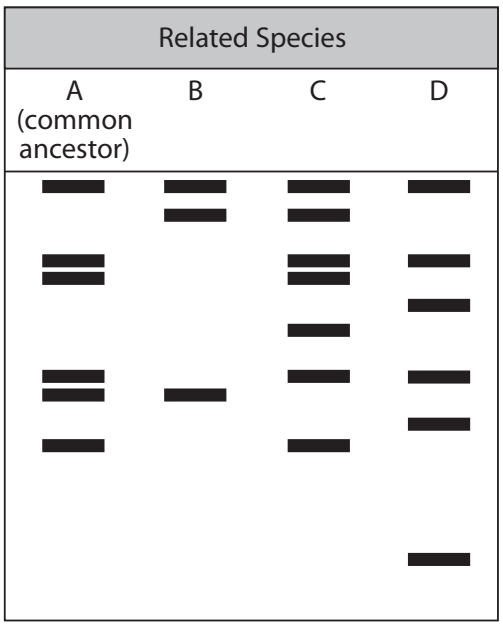
☒ **C** smallest fragment of DNA that travelled the fastest

☒ **D** smallest fragment of DNA that travelled the slowest

(b) Gel electrophoresis of DNA can be used to study the evolutionary relationships between species.

Scientists used gel electrophoresis to examine the relationship between four species: A, B, C and D.

The diagram shows the results.



Explain which species is most closely related to the common ancestor using these results.

(3)

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(c) Describe evidence, other than the gel electrophoresis of DNA, that a scientist could use to establish the evolutionary relationships between species.

(4)

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4 Biologists use systems of classification to group organisms together.

(a) (i) Which of the following is a domain?

(1)

- ☒ **A** Archaea
- ☒ **B** Fungi
- ☒ **C** Insecta
- ☒ **D** Plantae

(ii) Which of the following groups is **not** in the domain Eukaryota?

(1)

- ☒ **A** Animalia
- ☒ **B** Bacteria
- ☒ **C** Insecta
- ☒ **D** Mammalia

(iii) Which of the following represents the correct hierarchy for classification?

(1)

- ☒ **A** domain, kingdom, phylum, class, order, family, genus, species
- ☒ **B** domain, kingdom, phylum, order, class, family, genus, species
- ☒ **C** kingdom, domain, phylum, class, order, family, genus, species
- ☒ **D** kingdom, domain, order, phylum, class, family, genus, species

(b) Describe the peer review process used by scientists to validate evidence for a new species.

(2)

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(c) Explain the advantages and disadvantages of using zoos in the conservation of endangered animals.

(3)

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6 The photograph shows a brown rat, *Rattus norvegicus*.

(Source: © DK IMAGES/SCIENCE PHOTO LIBRARY)

(a) The classification hierarchy for the brown rat is:

- Domain: Eukarya
- Kingdom: Animalia
- Phylum: Chordata
- Mammalia
- Rodentia
- Muridae
- Genus: *Rattus*
- Species: *norvegicus*.

(i) Which family, order and class does the brown rat belong to?

(1)

	Family	Order	Class
☒ **A**	Mammalia	Muridae	Rodentia
☒ **B**	Mammalia	Rodentia	Muridae
☒ **C**	Muridae	Rodentia	Mammalia
☒ **D**	Muridae	Mammalia	Rodentia

(ii) State **one** method that scientists use to determine the evolutionary relationships of the brown rat compared with other species.

(1)

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(b) Warfarin is a poison that is often used to control brown rat populations.

In areas where large amounts of warfarin have been used, many rats have developed resistance to warfarin.

Three genotypes occur in rat populations:

W^NW^N – rats that are not resistant to warfarin

W^RW^R – rats that are resistant to warfarin but require large amounts of vitamin K in their diet to survive

W^NW^R – rats that are resistant to warfarin and **do not** require large amounts of vitamin K to survive.

After the introduction of warfarin, scientists determined the change in numbers of rats that were resistant to warfarin, and the number that were not resistant to warfarin.

The table shows their results.

Type of rat	Genotypes of rats	Number of rats		
		before warfarin was used	two years after warfarin use started	five years after warfarin use started
Resistant to warfarin	W^RW^R and W^NW^R	35	195	180
Not resistant to warfarin	W^NW^N	265	105	120

(i) Calculate the expected number of rats that would be resistant to warfarin but **do not** require large amounts of vitamin K to survive, before warfarin was used.

Use the Hardy-Weinberg equation

$$p^2 + 2pq + q^2 = 1$$

(3)

Answer .....

(ii) Explain why, after two years, there is a change in the number of rats that are resistant to warfarin.

(2)

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(iii) Warfarin is highly toxic to rats that have no resistance.

Explain why, after five years, there are still many rats that are not resistant to warfarin.

(2)

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6 (a) A species may be defined as a group of organisms with similar characteristics that interbreed to produce fertile offspring.

Explain the limitations of this definition.

(3)

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(b) The evolutionary relationship between species can be determined using gel electrophoresis.

Which of the following describes the movement of DNA fragments in gel electrophoresis?

(1)

☒ **A** all fragments travel the same distance

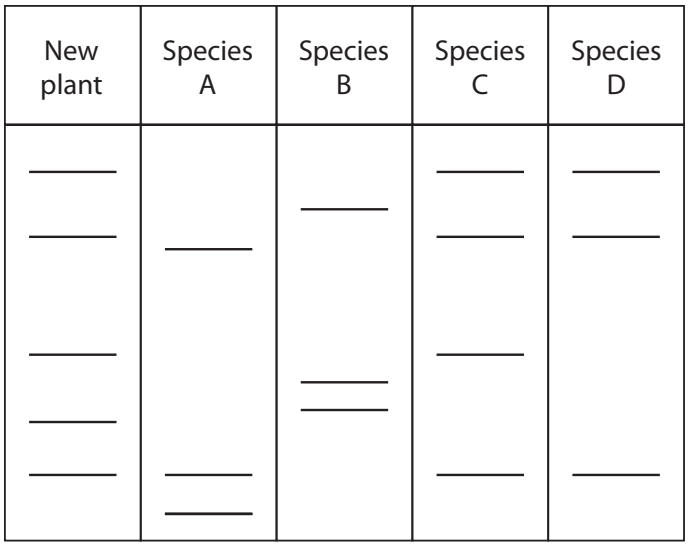
☒ **B** larger fragments travel faster than smaller fragments

☒ **C** larger fragments travel further than smaller fragments

☒ **D** smaller fragments travel further than larger fragments

(c) Scientists discovered a new plant. They wanted to determine if this plant was a new species related to one or more of four known plant species.

The diagram shows the results of gel electrophoresis of DNA samples from the new plant and the four known plant species, A, B, C and D.



(i) Analyse the data to assess whether the new plant is a new species.

(4)

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(ii) Describe **two** other pieces of information the scientists could use to confirm if the new plant is a new species.

(2)

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7 There are currently only three surviving species of elephant:

- Asian elephant, *Elephas maximus*
- African bush elephant, *Loxodonta africana*
- African forest elephant, *Loxodonta cyclotis*

(a) Complete the table showing the classification of the African bush elephant.

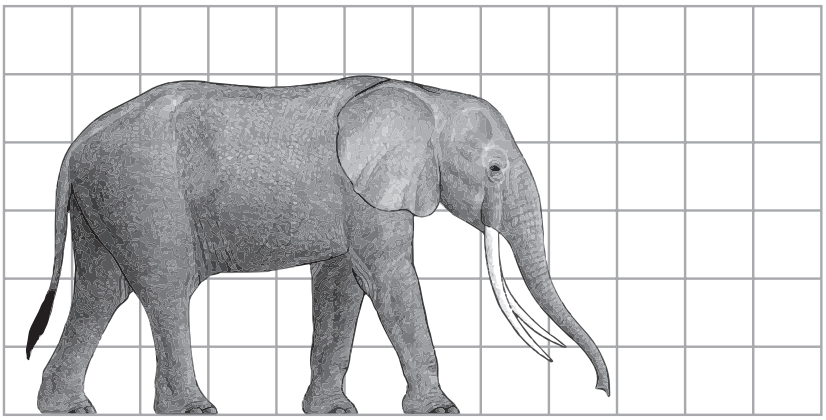
(2)

Domain	.....
Kingdom	Animalia
Phylum	Chordata
.....	Mammalia
Order	Proboscidae
Family	Elephantidae
Genus	.....
Species	.....

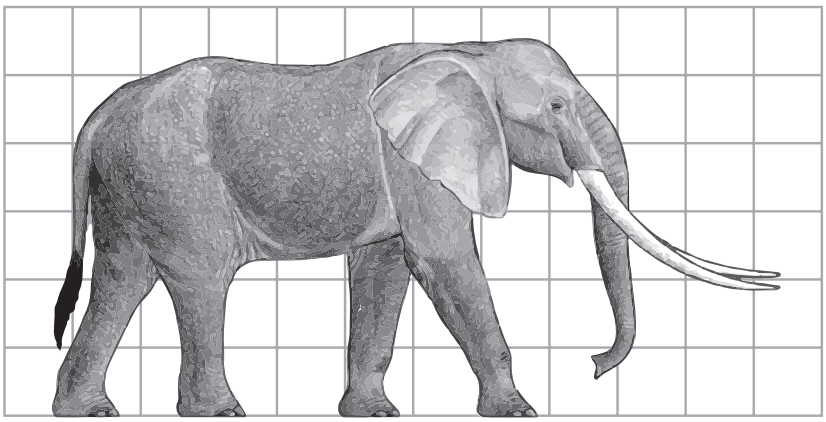
(b) All African elephants used to be classified as a single species.

Recent comparisons of African elephants demonstrated that they are two separate species.

The diagrams show the appearance and locations of the two African elephant species.



African bush elephant



African forest elephant

(i) Give one reason why scientists used to classify African elephants as a single species.

(1)

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(ii) Scientists agreed to separate the African elephants into two species based on new evidence from DNA sequencing.

State how scientists reach agreement on new evidence.

(1)

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(c) Recently, scientists extracted mitochondrial DNA from a frozen Arctic mammoth.

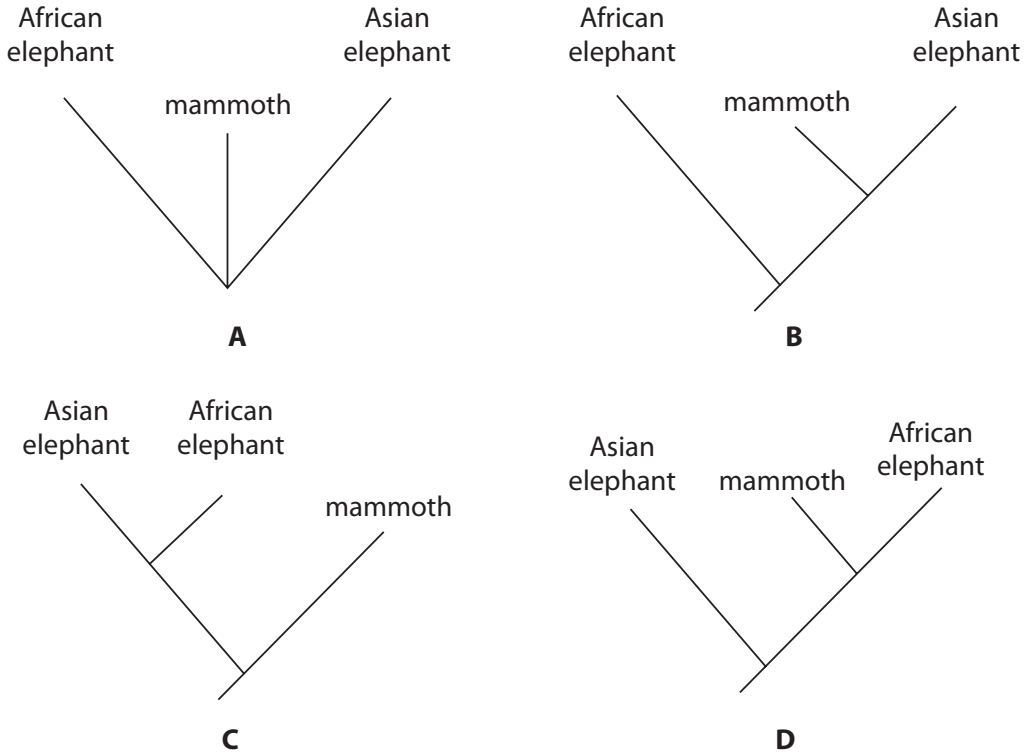
This DNA was sequenced and compared with the mitochondrial DNA from the Asian elephant and from the African bush elephant.

The percentage similarities in the DNA sequences are shown in the table.

Species	**Percentage similarity in DNA sequence (%)**		
	Mammoth	**Asian elephant**	**African bush elephant**
Mammoth	100	98	96
Asian elephant	98	100	95
African bush elephant	96	95	100

Which diagram shows the correct evolutionary relationship for these three species, based on the data in the table?

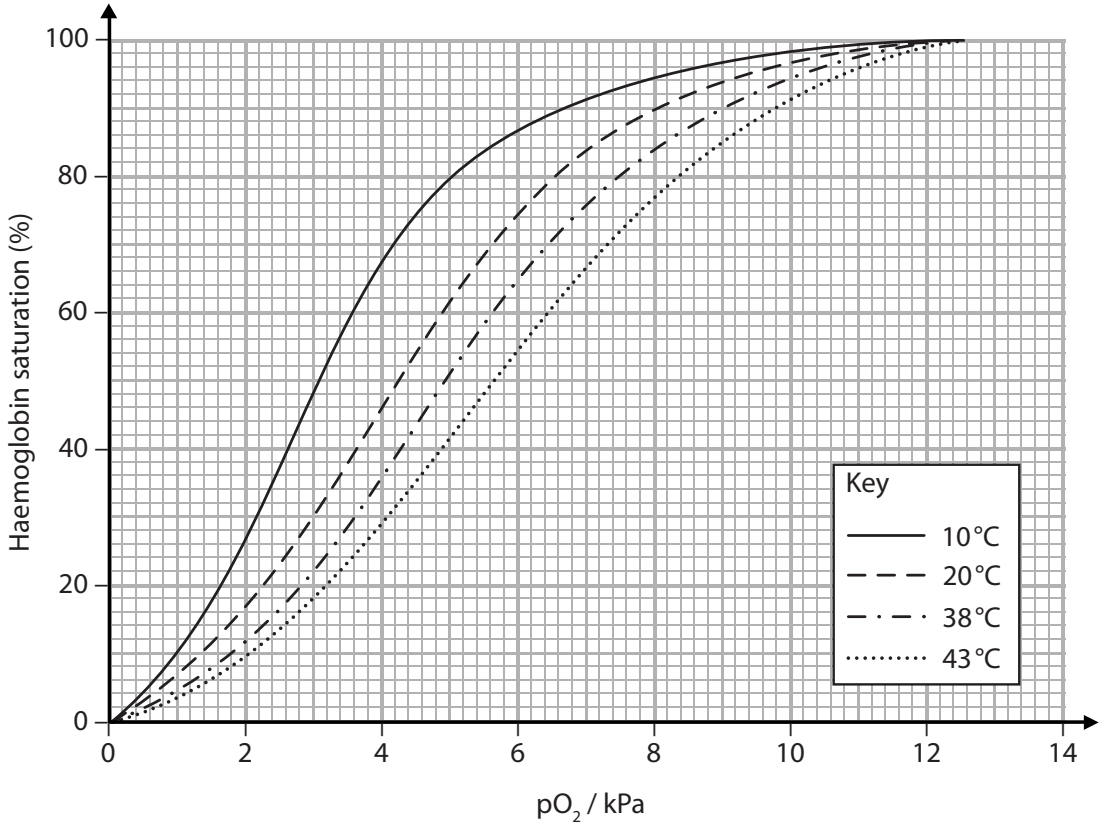
(1)



- ☐ A
- ☐ B
- ☐ C
- ☐ D

(d) Scientists also investigated the effect of temperature on the percentage saturation of haemoglobin with oxygen, using blood from an Asian elephant.

The oxygen dissociation curves are shown in the graph.



(i) In the alveolar capillaries, the partial pressure of oxygen is 12 kPa at a temperature of 38 °C and haemoglobin is fully saturated with oxygen.

In active muscle tissue, the partial pressure of oxygen is 2 kPa at a temperature of 43 °C.

Use the graph to determine the percentage saturation of haemoglobin in active muscle tissue.

(1)

Answer ..... %

(ii) When 1g of haemoglobin is fully saturated it carries 1.3 cm^3 of oxygen.

Calculate the volume of oxygen released by 1 g of haemoglobin to this active muscle tissue.

Show your working.

(2)

Answer .....

(iii) Scientists extracted the genes for mammoth haemoglobin and used them to produce mammoth haemoglobin.

The oxygen dissociation curve for mammoth haemoglobin at 38 °C was found to be the same as for the Asian elephant at 38 °C.

Lowering the temperature did not shift the oxygen dissociation curve.

Explain how these observations show that this haemoglobin enabled mammoths to be adapted for life in cold Arctic regions.

(3)

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(Total for Question 7 = 11 marks)

5 Taxonomy defines and names groups of organisms.

(a) The correct hierarchy of classification categories is

(1)

☒ **A** domain, kingdom, phylum, class, order, family, genus, species

☒ **B** domain, kingdom, phylum, order, class, family, genus, species

☒ **C** kingdom, domain, order, phylum, class, genus, family, species

☒ **D** kingdom, phylum, domain, order, class, family, genus, species

(b) (i) Describe the information scientists can use to classify an organism as a new species.

(4)

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(ii) Explain why it may be difficult to classify a newly discovered organism as a separate species.

(2)

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(c) The hawthorn fly is found in a part of North America.

The hawthorn fly has separated into two species.

One species is called the apple maggot fly and feeds on apples. The other species is called the hawthorn fly and feeds on hawthorn fruit.

The photographs show these two species.

Apple maggot fly

Hawthorn fly

Explain how these two species have evolved.

(3)

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(d) Changes in the number of chromosomes of lizards can occur, resulting in speciation.

Some lizards are tetraploid (4n) rather than diploid (2n).

Explain how this speciation has arisen.

(2)

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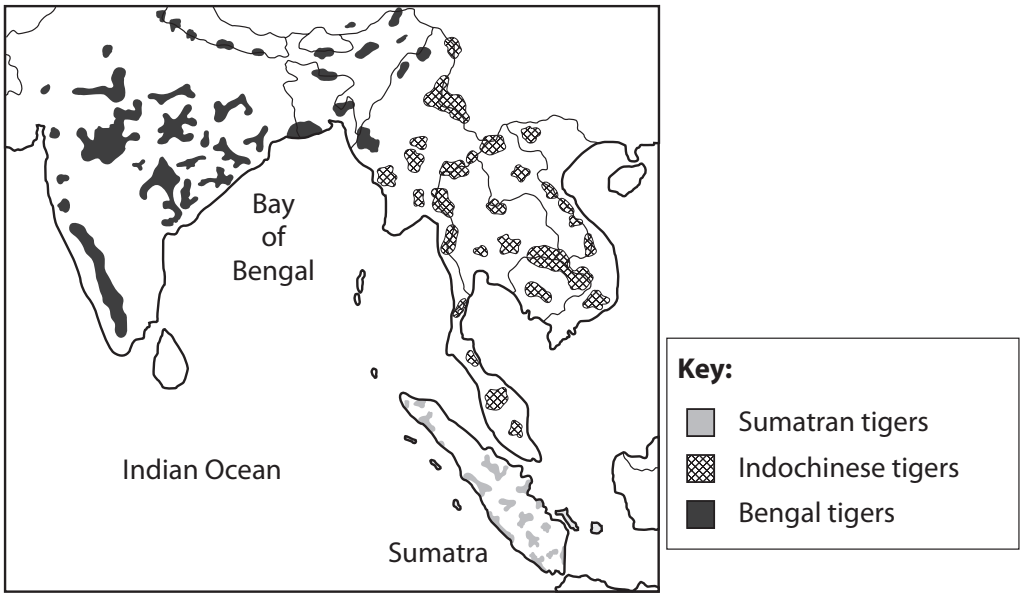
SUB-TOPIC 3(b)

NATURAL SELECTION, EVOLUTION AND SPECIATION

14 questions in this sub-topic · 149 marks · lowest tariff first

9 Before the twentieth century, tigers were once widespread across the whole of South and South East Asia. Over the last hundred years, their geographical distribution has been reduced by over 90%. The diagram shows the current distribution of three varieties of tiger.



(a) Use the map to explain how the different varieties of tiger may eventually become separate species.

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(b) The development of palm oil plantations in Sumatra has removed areas of forest that provided the natural habitat for these tigers.

Many tigers in Sumatra suffer from inherited disorders.

Explain why planting strips of trees to link the remaining patches of forest would have an effect on the frequency of genetic disorders in these tigers.

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6 The photograph shows a species of insect, *Gryllus pennsylvannicus*.

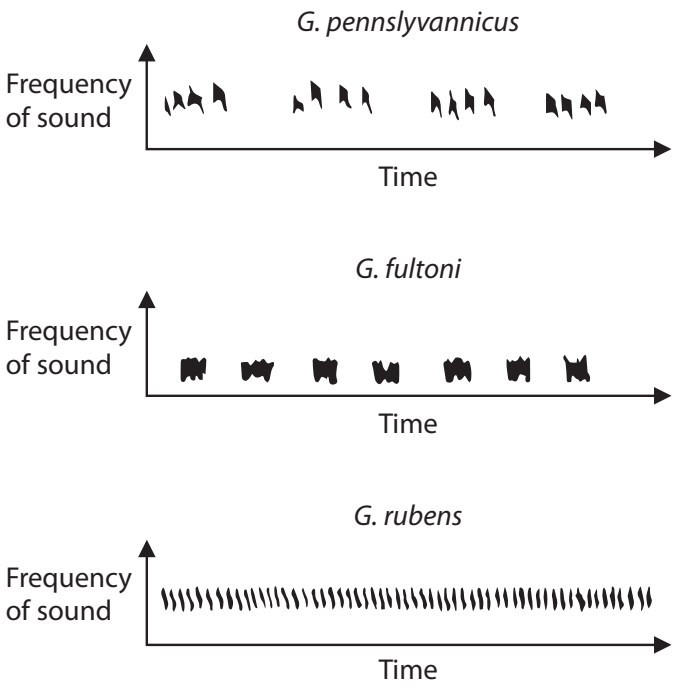
Scientists used to think that *G. pennslyvannicus* and two other species, *G. fultoni* and *G. rubens*, belonged to the same species.

The insects live in North Carolina in the USA.

Scientists have produced evidence that these insects have evolved into three distinct species from a common ancestor.

They recorded the male mating calls of each species and produced a graph representing the sound made. The graph is called a sonogram.

The diagram shows the sonogram for each species.



(a) Explain how the insects evolved from a common ancestor into three distinct species.

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(b) Explain how gel electrophoresis could be used to identify which species is most closely related to the common ancestor.

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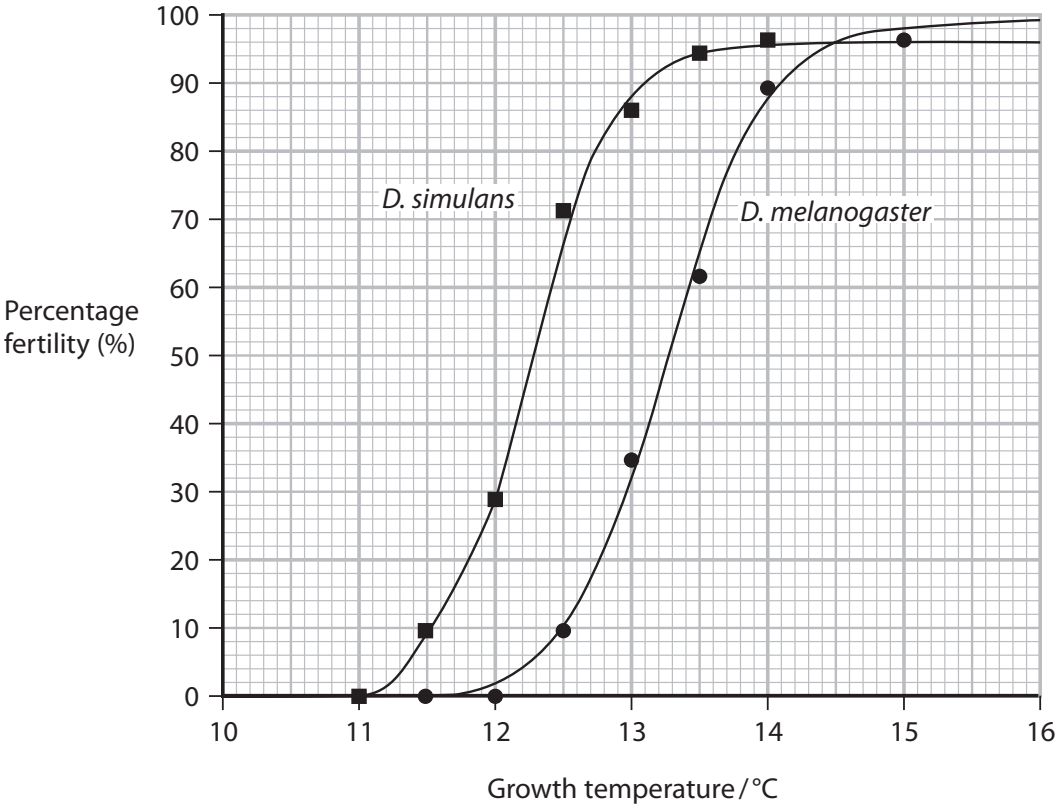
8 The photograph shows a fruit fly, *Drosophila*.

(Source: © Roblan/Shutterstock)

Species of *Drosophila* live in a range of habitats in different parts of the world.

The geographic distribution of these species ranges from regions with low temperatures to regions with high temperatures.

The graph shows the effect of temperature on the percentage fertility of male flies of two species of *Drosophila*, *D. simulans* and *D. melanogaster*.



(a) The effect of low temperature on fertility is often compared using the temperature that results in 50% fertility.

Determine the difference in these temperatures for the two species.

(1)

Temperature difference .....

(b) Scientists also collected data from the two species about the effect of both high and low temperature on the viability of eggs and fertility of male flies.

An egg is viable if it develops into an adult.

The table shows the effects of temperature on the viability of eggs and fertility of males, for the two species of *Drosophila*.

Species	Lowest temperature / °C		Highest temperature / °C	
	at which eggs are viable	at which males are fertile	at which eggs are viable	at which males are fertile
D. melanogaster	10	12	32	30
D. simulans	10	11	31	28

(i) Give the relationship between temperature and the viability of eggs and fertility of males.

(1)

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*(ii) Another group of scientists recorded the courtship song of male *D. melanogaster* and male *D. simulans*.

The male flies vibrate their wings producing a courtship song to attract females.

The courtship song is produced in pulses.

The interval between pulses and the duration of each pulse are shown in the table.

Species	Mean interval between pulses / ms	Duration of pulse / s
D. melanogaster	34.1	1.6
D. simulans	48.9	3.4

Discuss how the data provides evidence for the geographical distribution and type of speciation of the two species of *Drosophila*.

Use the data from tables for temperature and for courtship song.

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7 The diagram shows four varieties of rabbit.

Brown Chinchilla Himalayan Albino

Fur colour in rabbits is controlled by four different alleles:

- the allele for brown fur, C, is dominant to all other alleles
- the allele for chinchilla fur, c^{ch}, is dominant to the alleles for Himalayan and albino
- the allele for Himalayan fur, c^{h}, is dominant to the allele for albino
- the allele for albino fur, c, is recessive to all other alleles

(a) (i) Describe how new combinations of alleles are produced in meiosis.

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(ii) State all the possible genotypes of a rabbit with brown fur.

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(iii) Two parent rabbits with brown fur were mated. Two of the F_1 offspring had chinchilla fur.

The F_1 rabbit offspring with chinchilla fur were mated.

The F_2 generation consisted of some rabbits with chinchilla fur and the rest having Himalayan fur.

Use genetic crosses to deduce the genotypes of the two parent rabbits with brown fur.

(3)

Answer .....

(b) The fur colour of animals can be affected by natural selection.

Compare and contrast stabilising selection with disruptive selection.

(3)

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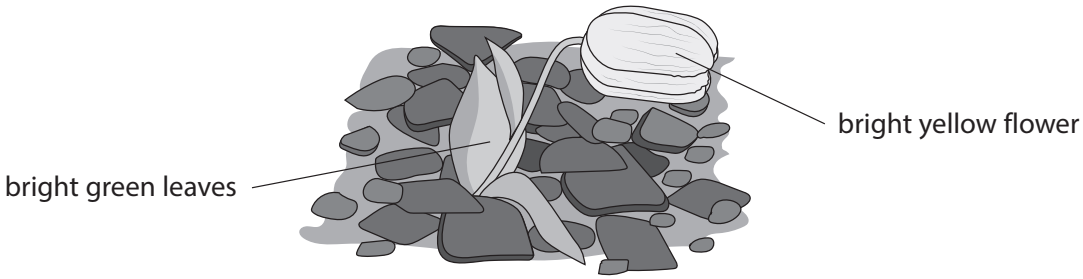
6 *Fritillaria delavayi* is a small plant (height 7 cm), that grows on rocky slopes on mountains in China.

The image shows *Fritillaria delavayi*.



For at least 2 000 years, this plant has been collected and used in Chinese medicine. It is not known to be eaten by animals.

In less accessible regions, where few humans go, the plants are bright green with bright yellow flowers.

In locations where bulbs are collected in high numbers, most plants have greyish-brown leaves and flowers.

Scientists believe that the greyish-brown plants are the same species as the brightly-coloured plants.

(a) Explain why most of the plants in areas where bulbs are collected in high numbers have greyish-brown leaves and flowers.

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(b) (i) Describe how scientists can use gel electrophoresis to show that these plants belong to the same species.

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(ii) Explain why the features of the brightly-coloured plants enable them to grow successfully in the areas where they are not collected by humans.

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4 Crickets are medium-sized insects, similar to grasshoppers. They are found in many parts of the world.

Scientists studied the factors that are associated with mating behaviour in two related species of cricket, *Gryllus rubens* and *Gryllus texensis*.

These species can exist as allopatric and sympatric populations.

The male crickets produce a courtship 'song' to attract females.

This song is different for each species.

The scientists compared mating behaviour of male crickets.

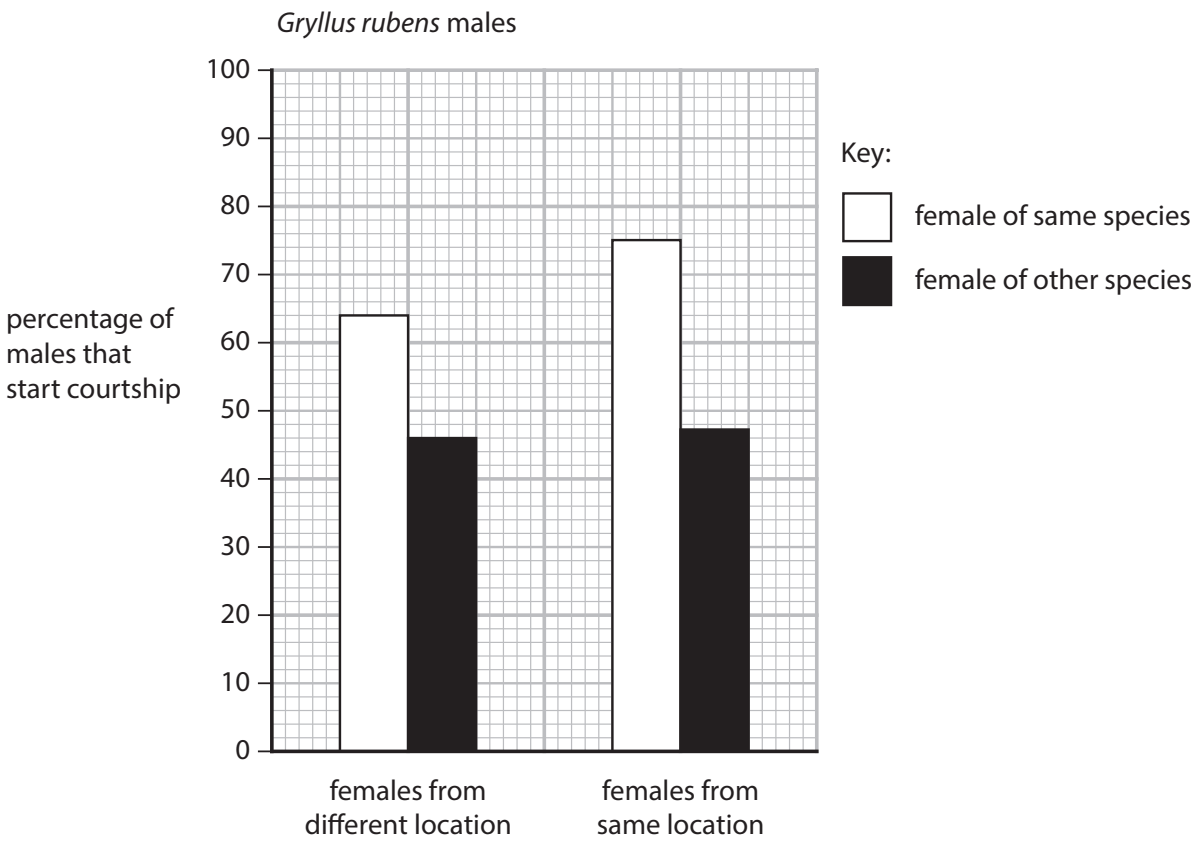
They did this for sympatric and allopatric populations.

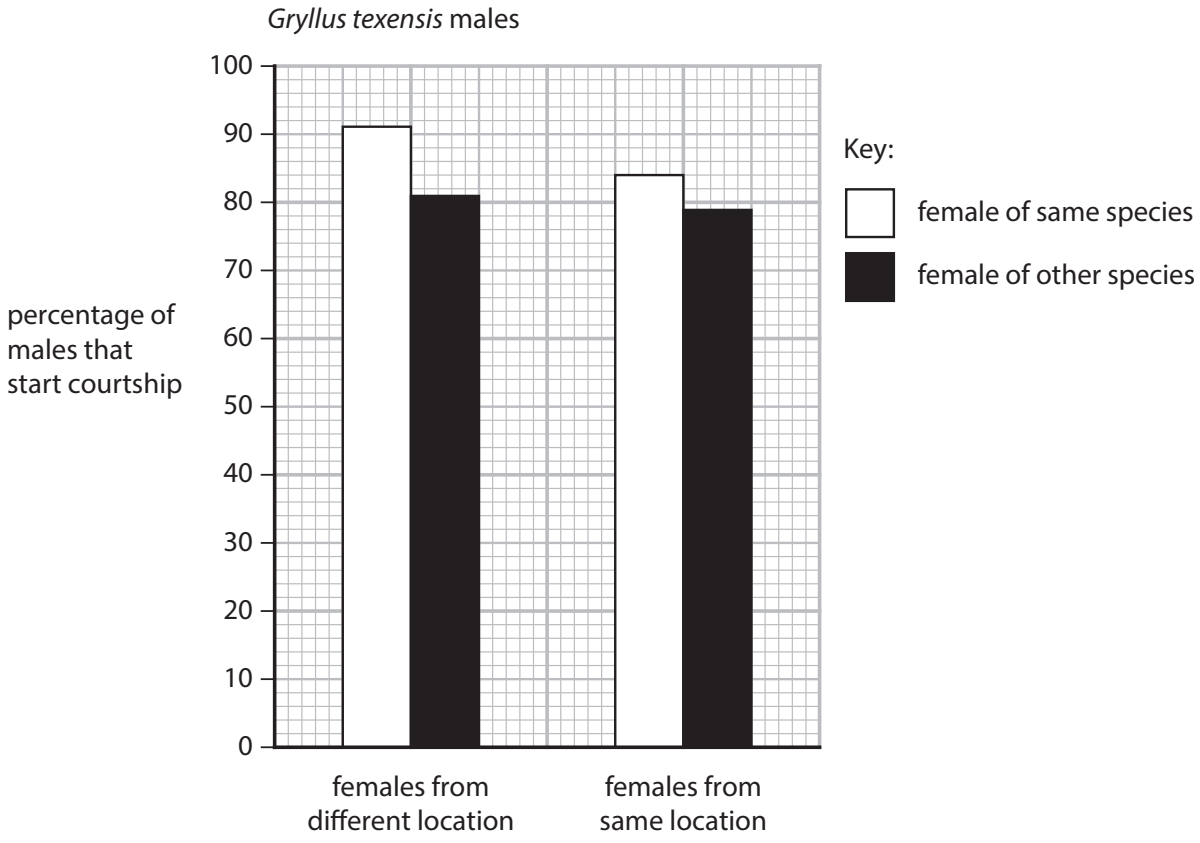
Male crickets of each species were placed with:

- Females of the same species that were from different locations
- Females of the same species that were from the same location
- Females of the other species that were from different locations
- Females of the other species that were from the same location.

The percentage of males that began mating behaviour was calculated.

The results are shown in the graphs.


Gryllus rubens males
percentage of males that start courtship
100
90
80
70
60
50
40
30
20
10
0
females from different location
females from same location
Key:
female of same species
female of other species


Gryllus texensis males
percentage of males that start courtship
100
90
80
70
60
50
40
30
20
10
0
females from different location
females from same location
Key:
female of same species
female of other species

(a) Give the difference between allopatric and sympatric populations.

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(b) Explain how the courtship songs of male crickets may have evolved by natural selection.

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*(c) Analyse the information and data to comment on how male courtship behaviour could affect speciation in these crickets.

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4 Taxonomy is the branch of biology concerned with classifying organisms.

Scientists use a variety of methods to classify organisms into groups.

(a) Which of the following groups contains the largest number of different types of organism? **(1)**

☒ **A** class

☒ **B** order

☒ **C** phylum

☒ **D** species

(b) Which of the following contributes to evolution by natural selection? **(1)**

☒ **A** all organisms have enough resources to survive

☒ **B** individuals in the same population show little variation

☒ **C** individuals inherit acquired characteristics

☒ **D** organisms produce many more offspring than survive

(c) One definition of a species is a group of organisms that has similar features and **(1)**

☒ **A** can mate to produce hybrid offspring

☒ **B** can produce fertile offspring

☒ **C** live in the same location

☒ **D** have no genetic variation

(d) Which molecules are separated using gel electrophoresis when classifying organisms? **(1)**

☒ **A** DNA

☒ **B** lipids

☒ **C** polysaccharides

☒ **D** vitamins

(e) The photograph shows three head lice on human hair.

Source: www.shutterstock.com

Insecticides are used to control the spread of head lice.

However, commonly used insecticides have become less effective at reducing head lice populations.

(i) Explain why these insecticides have become less effective when used to treat head lice.

(4)

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(ii) Explain how the use of insecticides could be changed to make the treatment more effective.

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6 Natural selection can lead to adaptations in organisms.

(a) Explain how evolution can occur through natural selection.

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(b) (i) Which of the following is an example of a behavioural adaptation?

(1)

☒ **A** courtship display in sticklebacks

☒ **B** litter size in pigs

☒ **C** number of *Drosophila* eggs that hatch

☒ **D** pollen production in sycamore trees

(ii) Which of the following is an example of anatomical adaptation?

(1)

☒ **A** an alarm call by a song thrush

☒ **B** dominance behaviour in dairy cattle

☒ **C** limb structure in primates

☒ **D** water potential in root hair cells

(iii) Which of the following is an example of physiological adaptation?

(1)

- ☒ **A** increased number of stomata on leaf upper surface in a water lily
- ☒ **B** production of venom by a snake
- ☒ **C** reduction of leaves to spines in a cactus
- ☒ **D** salmon swimming upstream to mate

(c) Natural selection can lead to speciation.

(i) Which information about a new organism would to lead to it being classified as a new species?

(1)

- ☒ **A** anatomical differences
- ☒ **B** behavioural differences
- ☒ **C** genetic differences
- ☒ **D** inability to produce fertile offspring with similar species

(ii) Give one method that a scientist might use to inform the scientific community about the discovery of a new species.

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(d) Compare and contrast allopatric and sympatric speciation.

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4 The photograph shows an insect fossilised in amber resin.

(Source: Bjoern Wylezich. 123rf.com/PAL)

Scientists have classified another fossilised insect found in amber resin as a new species of mosquito, *Priscoculex burmanicus*.

This mosquito is anatomically very similar to modern species of mosquito.

(a) (i) Which of these processes produces new species without geographically separating populations?

(1)

☒ **A** allopatric speciation

☒ **B** genetic speciation

☒ **C** stabilising speciation

☒ **D** sympatric speciation

(ii) *Priscoculex burmanicus* became extinct about 100 million years ago.

State why it was difficult for scientists to decide if this insect belonged to a different species from modern mosquitoes.

(1)

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(iii) State how scientists would have reached agreement on classifying this mosquito.

(1)

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(iv) Complete the classification table for *Priscoculex burmanicus*.

(2)

Taxon	Name
Domain	Eukarya
Kingdom	Animalia
	Arthropoda
	Diptera
Order	Culicidae
Family	Anophelinae
Genus	
Species	

(b) Mosquito populations are often controlled using pesticides that inhibit the enzyme acetylcholinesterase.

Long-term use of pesticides often leads to the development of resistance in these mosquitoes.

The ace-1 gene codes for the enzyme acetylcholinesterase.

The ace-1^r allele is a recessive form of this gene that gives resistance to pesticides.

The changes in the numbers of resistant and non-resistant mosquitoes in an area of farmland where pesticides were used in 2007 was investigated.

The use of the pesticides was stopped in 2016.

The table shows the results of this investigation.

Mosquito type	Number of mosquitoes		
	2005	2015	2018
resistant	125	5250	4120
non-resistant	8755	1250	3950

(i) Calculate the number of heterozygous mosquitoes in 2015.

Use the Hardy-Weinberg equation

$$p^2 + 2pq + q^2 = 1$$

(3)

Answer.....

(ii) Explain why the changes in the numbers of the resistant and non-resistant mosquitoes, from 2005 to 2018, are related to the function of the ace-1 gene.

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8 The photograph shows a satin bowerbird, *Ptilonorhynchus violaceus*, in its bower.

(Source: ©Imogen Warren / Shutterstock)

(a) The classification hierarchy for the satin bowerbird is:

Eukarya

Animalia

Chordata

Aves

Passeriformes

Ptilonorhynchidae

Ptilonorhynchus

violaceus

(i) Which of these is the phylum for the satin bowerbird?

(1)

☐ **A** Animalia

☐ **B** Chordata

☐ **C** Eukarya

☐ **D** Vertebrata

(ii) Which of these is the genus for the satin bowerbird?

(1)

☒ **A** Aves

☒ **B** Bower

☒ **C** *Ptilonorhynchus*

☒ **D** *violaceus*

(b) The males are known for building and decorating a bower to attract females.

This is made of two parallel walls of sticks and is used as a courtship arena during the breeding season.

The male decorates the bower with bright blue coloured objects that it collects. Blue clothes pegs, drinking straws and bottle tops are among the favourite items.

Away from human habitation, bright blue parrot feathers, flowers and snail shells make up the majority of the decorations.

(i) Describe how courtship ensures that bowerbirds mate successfully.

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(ii) Explain how this bower building behaviour has evolved by natural selection.

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(iii) Devise an investigation to determine the effect of changing the colour of the objects used to decorate the bower on its attractiveness to female bowerbirds.

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7 The photograph shows a tawny owl. These owls live in areas close to the Arctic Circle.

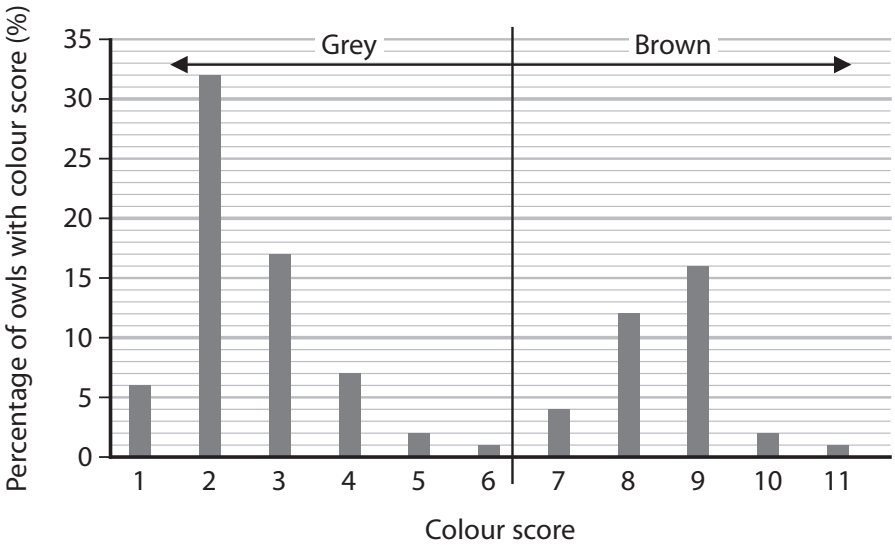
(Source: © LINDA WRIGHT/SCIENCE PHOTO LIBRARY)

Scientists investigated the feather colours of a population of tawny owls. Feather colours of the owls were scored on a scale of 1 to 11, according to how grey or brown they were.

Grey feathered owls were given a score between 6 and 1, with 1 being the most grey.

Brown feathered owls were given a score between 7 and 11, with 11 being the most brown.

The graph shows the percentages of owls in the population with each of the colour scores.



(a) The scientists concluded that feather colour in owls is controlled by a single genetic locus. The brown allele is dominant to the grey allele.

(i) State what is meant by a dominant allele.

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(ii) Explain the range of feather colours, shown in the graph, in this population of owls.

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(iii) In this population of 120 owls, 84 of them were grey.

Calculate the number of owls that are heterozygous for feather colour.

Use the Hardy-Weinberg equation

$$p^2 + 2pq + q^2 = 1$$

(3)

Answer .....

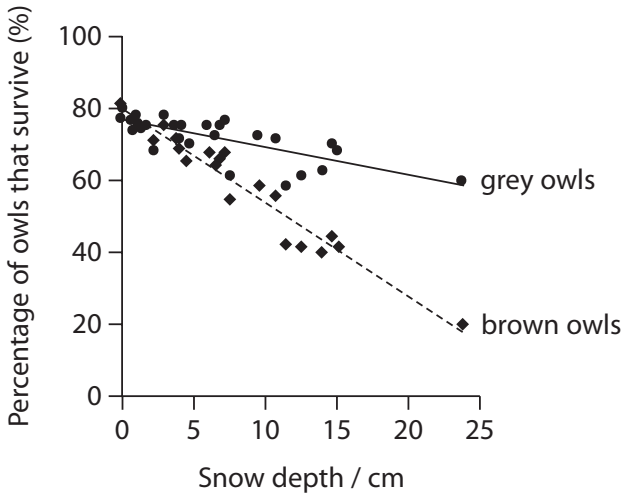
*(b) The scientists investigated the effect of climate change on the frequencies of these two alleles for feather colour in populations of tawny owls.

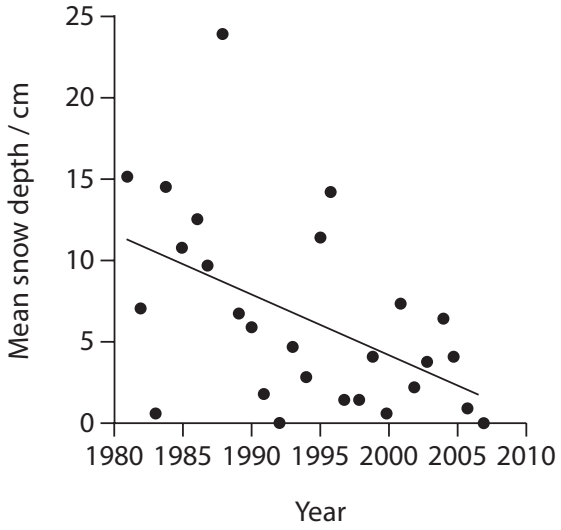
The percentage survival rates of both colours of owl were measured when there were different depths of snow.

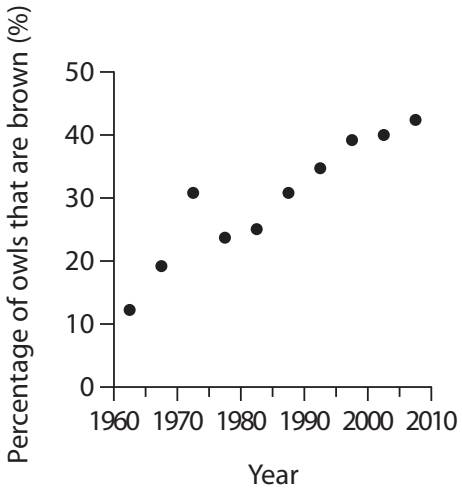
The mean depth of snow was recorded each year between 1980 and 2007.

The percentage of owls that were coloured brown between 1960 and 2007 was also recorded.

The graphs show the results.







The scientists concluded that increased greenhouse gases from human activity are resulting in an increase in the frequency of the brown allele.

Analyse the data to evaluate this conclusion.

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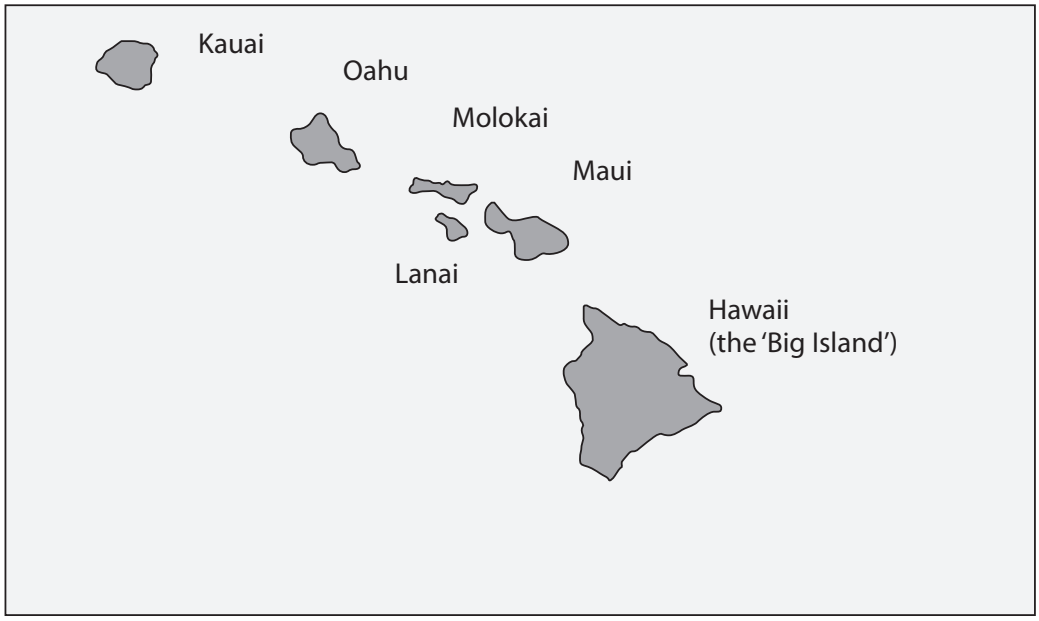
7 The map shows a group of islands found in the Pacific Ocean.



Drosophila silvestris and *Drosophila planitibia* are two related species of fly.

Drosophila silvestris is found only on Hawaii island and *Drosophila planitibia* is found only on Maui island.

These species occupy similar niches.

(a) Describe what is meant by the term niche.

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(b) Which groups do *Drosophila silvestris* and *Drosophila planitibia* belong in?

1. the same family
2. the same genus
3. the same order
4. the same phylum

(1)

- ☒ **A** 1 only
- ☒ **B** 1 and 2 only
- ☒ **C** 1, 2 and 3 only
- ☒ **D** 1, 2, 3 and 4

(c) When these two species of fly are crossed together, some of the offspring are sterile and some are fertile.

Explain how the production of some sterile and some fertile offspring may cause a problem in classifying these flies.

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(d) Explain how these two species evolved from a common ancestor.

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(e) Describe what additional information can be used to help clarify the evolutionary relationship between these two species of fly.

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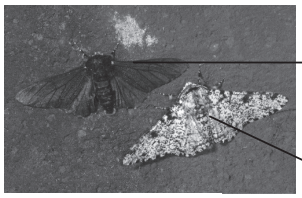
9 Peppered moths, *Biston betularia*, are found in many parts of the UK.
Two forms of this species are found, a light form and a dark form.

Peppered moths sometimes rest on tree trunks during the day. In rural areas with clean air, the tree trunks are often covered with lichen. In industrial areas the trees have less lichen on them due to air pollution.

The photographs show both forms resting on tree trunks.

Tree trunk in rural area

(Source: © MICHAEL W. TWEEDIE / SCIENCE PHOTO LIBRARY)



Tree trunk in industrial area

(Source: © STEPHEN DALTON / NATURE PICTURE LIBRARY / SCIENCE PHOTO LIBRARY)

Peppered moths are often preyed on by birds.

(a) Until 1848, light peppered moths were the only form recorded.

In 1848, a single darker form of the moth was observed in an industrial area in the north-west of England.
In 1895, 98% of peppered moths in this industrial area were the dark form.

Explain how natural selection could have led to these changes.

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*(b) Scientists have carried out several investigations to explain changes in the peppered moth populations.

Investigation 1: scientists placed both forms of the moths onto tree trunks in industrial and rural areas. They recorded the number of each type of moth eaten by birds.

The scientists found that on lichen-covered trunks, birds were twice as likely to eat dark moths as light moths.

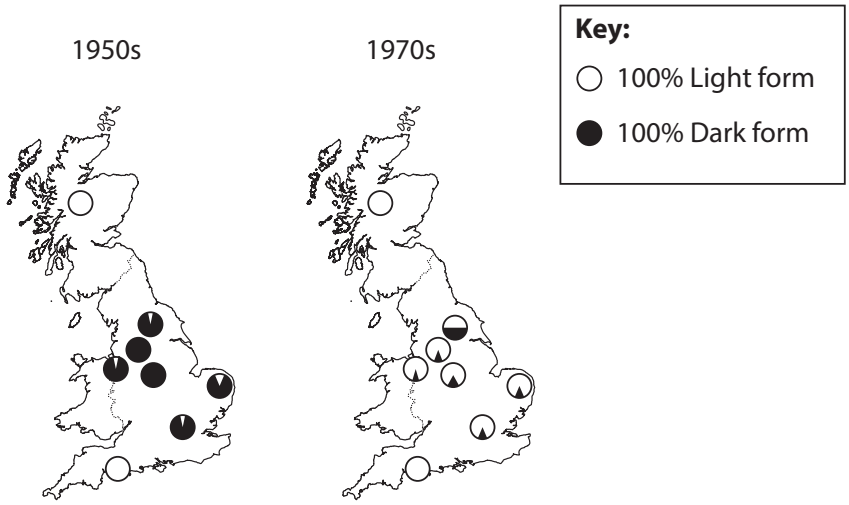
Investigation 2: scientists released marked peppered moths in an industrial area and in a rural area.

A few days later they trapped moths and calculated the percentage of trapped moths that were marked (recaptured moths). The table shows the results.

Type of peppered moth	Percentage of marked moths released which were recaptured (%)	
	Industrial area	Rural area
Light form	13.1	13.7
Dark form	27.5	4.7

Investigation 3: scientists collected data about the proportions of light and dark moths in different parts of England and Scotland in the 1950s and in the 1970s.

The maps show the results.



Investigation 3 found that in the 1970s there was a higher proportion of light moths than dark moths in areas that were once industrial, but the amount of lichen growing on tree trunks had not changed significantly.

Recent investigations have provided new evidence for the changes in the proportions of peppered moth:

- peppered moths do not typically rest on tree trunks during the day, but are more likely to rest on the underside of high branches
- the main predators of peppered moths are bats, not birds.

It has been suggested that the change in proportions of peppered moth forms is an example of natural selection.

Discuss the validity of this suggestion.

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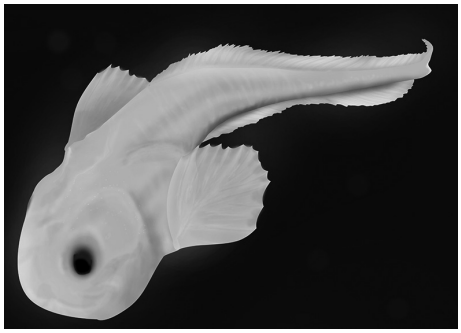
7 The Yap Trench is an area of very deep water in the Pacific Ocean.

In 2017, a new species of fish was caught in the Yap Trench. This was named the Yap hadal snailfish.

The photograph shows a different species of snailfish, the Mariana hadal snailfish.



(Source: © Adisha Pramod/Alamy Stock Photo)

(a) The Yap hadal snailfish was caught in a deep sea trench, at a depth of 7 000 m below sea level.

Hydrostatic pressure increases 100 kPa with every 10 m of depth.

Calculate the hydrostatic pressure at 7 000 m.

Give your answer in standard form.

(1)

Answer ..... kPa

(b) Analysis of the genome of the Yap hadal snailfish and the Mariana hadal snailfish showed that they were closely related.

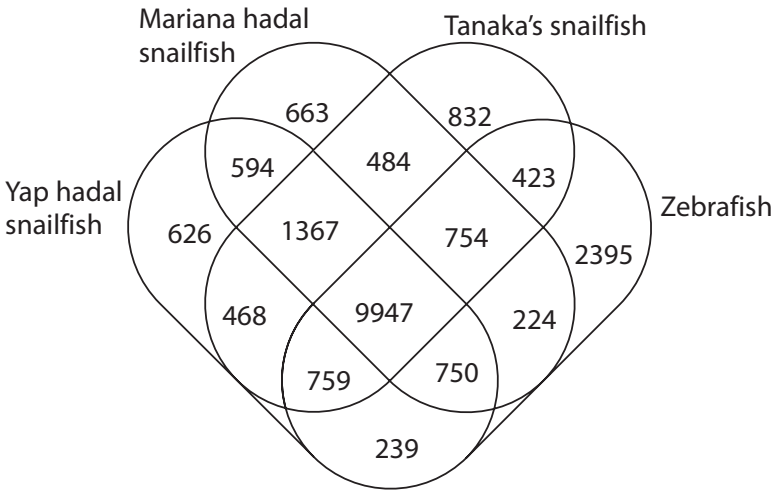
(i) The DNA from the Yap hadal snailfish contained 725 608 564 bases and 204 202 736 of these bases were adenines.

Calculate the number of guanine bases in the DNA of this fish.

(2)

Answer .....

(ii) The Venn diagram shows unique and shared gene families in the genomes of three species of snailfish and a zebrafish.



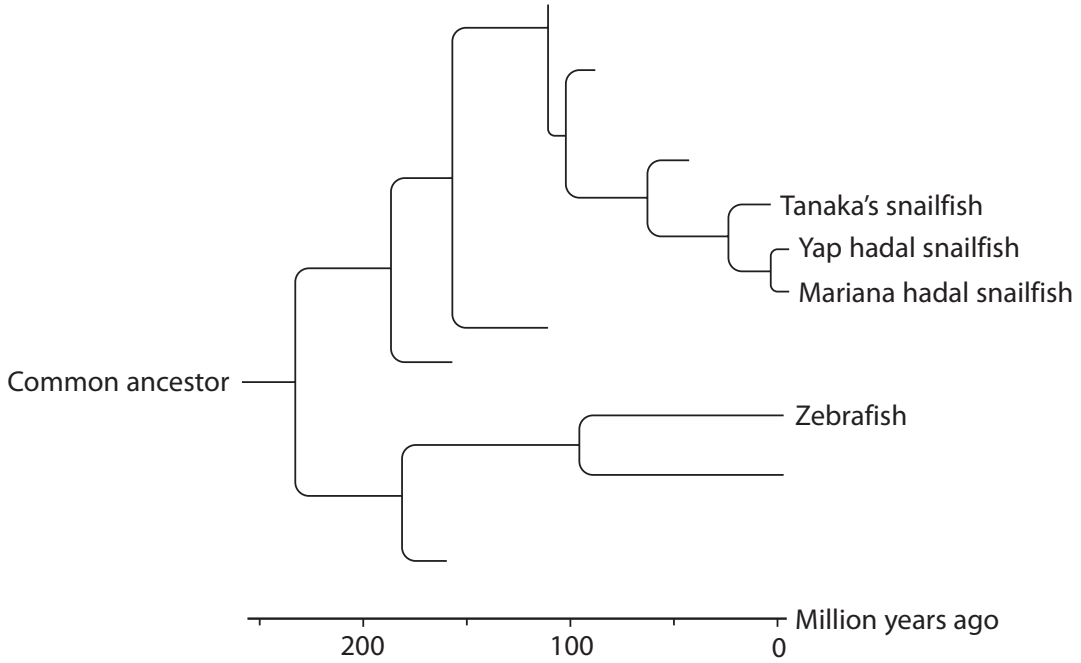
Calculate the percentage of gene families in the Yap hadal snailfish that are shared with the Mariana hadal snailfish.

Give your answer to one decimal place.

(2)

Answer .....%

(iii) The diagram shows the evolutionary relationship between three species of snailfish and a zebrafish.



Analyse the diagram to describe the evolutionary relationship between these four species of fish.

(3)

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*(iv) The Mariana hadal snailfish and the Yap hadal snailfish were caught in separate trenches hundreds of kilometres apart.

Explain how these fish evolved to become separate species.

(6)

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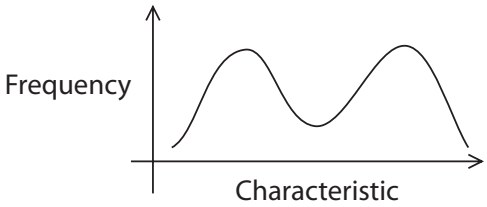
SUB-TOPIC 3(c)

BIODIVERSITY AND CONSERVATION

21 questions in this sub-topic · 262 marks · lowest tariff first

7 (a) The graph shows the frequency of a characteristic found in a population of animals.



Which type of selection would create this pattern?

(1)

☒ **A** allopatric selection

☒ **B** directional selection

☒ **C** disruptive selection

☒ **D** stabilising selection

(b) The Eurasian lynx is the largest native European cat species.

It was once widespread across Europe but is now restricted to small areas of national parks.

Ex-situ and *in-situ* conservation measures were used in the 1970s to increase biodiversity.

- Lynx were bred in zoos and 10 were reintroduced into an area of protected forest where the lynx had become extinct.
- Existing wild lynx were protected in an area of forest where they had not become extinct.

In 2016 scientists estimated the population sizes and genetic biodiversity of the lynx in these two areas of forest.

They found that the population and genetic biodiversity of the lynx in the area where they had been reintroduced were much lower than in the protected area.

(i) State what is meant by the term **biodiversity**.

(1)

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(ii) Explain why, in 2016, the genetic biodiversity of the lynx population in the area where they had been reintroduced was much lower than in the protected area.

(2)

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(c) Explain the principles and issues associated with *ex-situ* conservation methods.

(4)

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2 The biodiversity of habitats can be measured by recording the species present.

(a) Describe **two** reasons why biodiversity of habitats should be maintained.

(2)

1 .....

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2 .....

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(b) A student investigated the plant species growing in a sand dune habitat.

Plants were identified and counted in two regions, A and B, of the sand dune.

The results for region A are shown in Table 1.

Species	Number of individual plants
sea holly	8
sand couch	10
sea bindweed	2
sand dropwort	3
prickly parsnip	7

Table 1

The index of diversity (D) was calculated from the data.

This gave a value of 4.44.

The results for region B are shown in Table 2.

Species	Number of individual plants
sea holly	6
sand couch	7
sea bindweed	5
sand dropwort	8
prickly parsnip	4

Table 2

(i) Calculate the index of diversity (D) for region B using the formula

$$D = \frac{N(N-1)}{\Sigma n(n-1)}$$

(3)

Answer .....

(ii) Comment on the diversity of each region.

(3)

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4 Biodiversity can be measured within a habitat and within a species.

Students measured out a small area within woodland A. They then identified and counted the number of species present and the numbers of individuals of the different species in that area.

The table shows the results for woodland A.

Species	Number of individuals of each species
Woodrush	4
Holly	8
Bramble	1
Sedge	3
Ivy	4

(a) Calculate the index of diversity (D) for woodland A.

Use the formula:

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

where N = total number of organisms of all species
and n = total number of organisms of a particular species.

(3)

Answer .....

(b) The students then collected data from the same sized area in woodland B.

The table shows the results for woodland B.

Species	Number of each species
Woodrush	0
Holly	10
Bramble	4
Sedge	0
Ivy	4

The index of diversity (D) for woodland B was found to be lower than for woodland A.

Comment on the biodiversity of each woodland.

(3)

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(c) Describe how the students could modify their procedure to obtain a valid comparison of the diversity of each woodland.

(2)

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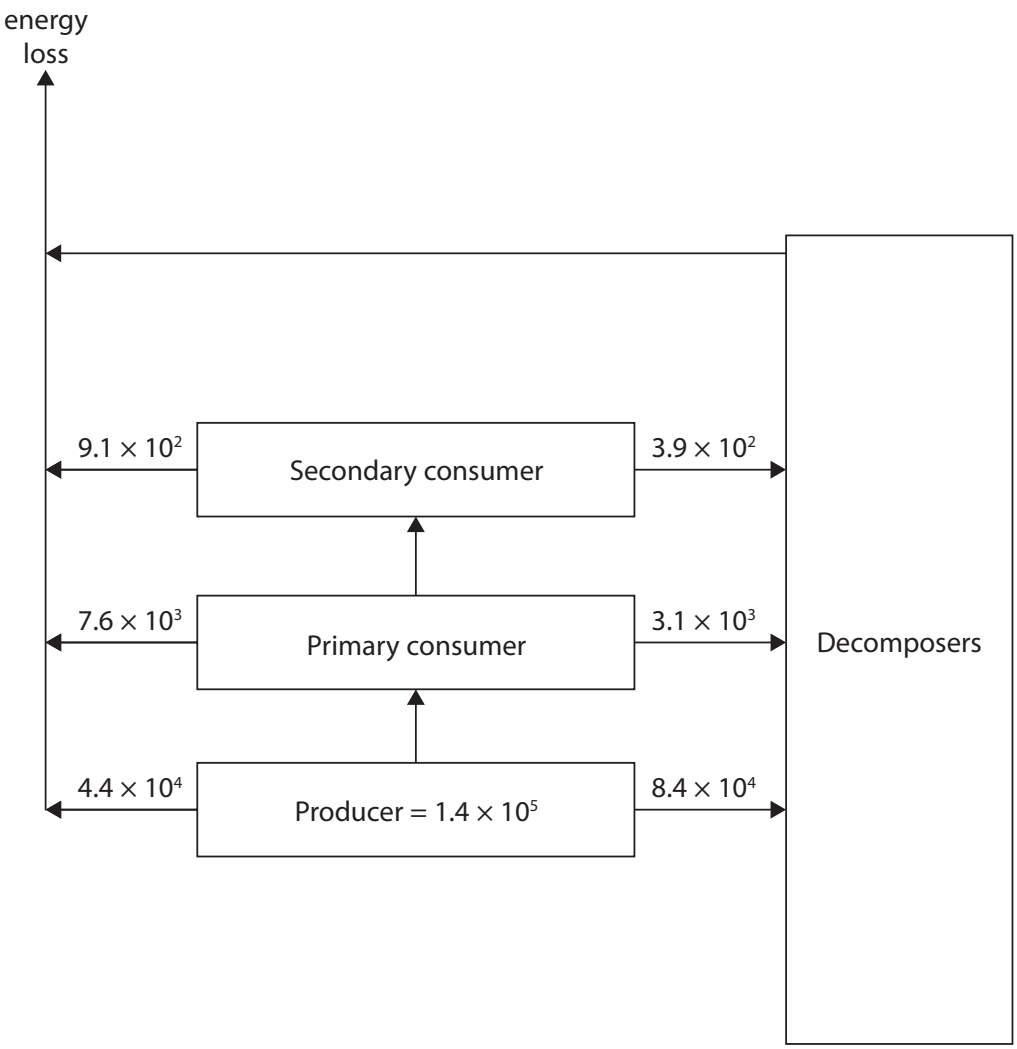
7 (a) (i) The diagram shows the transfer of energy through a grassland food chain.

All values are given in kJ m^{-2} yr^{-1}.



Calculate the percentage efficiency of the energy transfer from the producer to the primary consumer.

(2)

Answer.....

(ii) Explain the differences in the efficiency of energy transfer between the trophic levels in a food chain.

(3)

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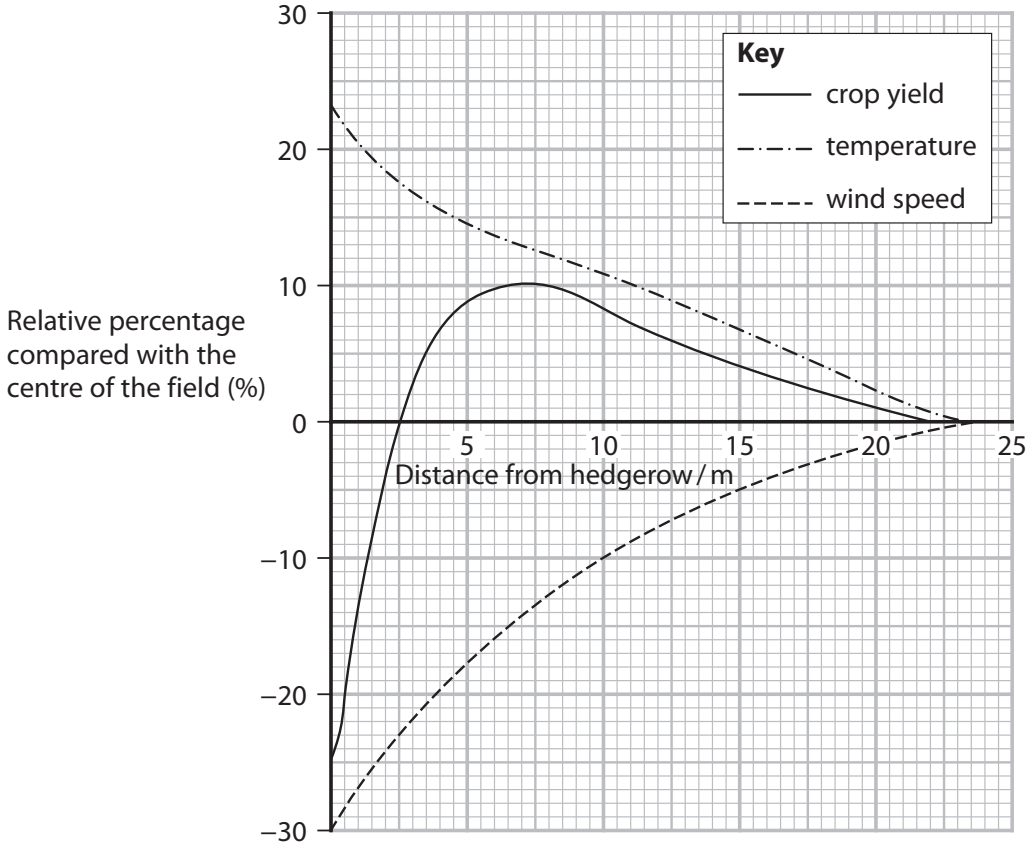
*(b) For many years, hedgerows have been removed to increase field sizes to grow crop plants.

Hedgerows provide a habitat for many species of plants and animals.

Some animals that live in hedgerows eat pests of crops and some pollinate crop plants.

The crop yield, temperature and wind speed were measured across the field starting at the hedge. These factors and the crop yield are shown as a relative percentage compared with the centre of the field in the graph.



Analyse the information to comment on the value of conserving hedges around fields used for growing crops.

(6)

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7 Scientists investigated the role of ex-situ conservation of plant species on genetic biodiversity.

The scientists investigated the variability of DNA sequences of 30 different genes for a number of species of plants in seed banks and in the wild.

(a) (i) Which row gives correct statements about the genetic code in eukaryotes?

(1)

		Overlapping	Degenerate	Contains introns in genes
☒	**A**	yes	yes	yes
☒	**B**	yes	no	yes
☒	**C**	no	yes	no
☒	**D**	no	yes	yes

(ii) Explain why the DNA sequences of genes are more variable than the sequences of amino acids in the proteins coded for by these genes.

(2)

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(iii) Describe how the scientists could use technology to find out whether gene sequences of two species are similar.

(2)

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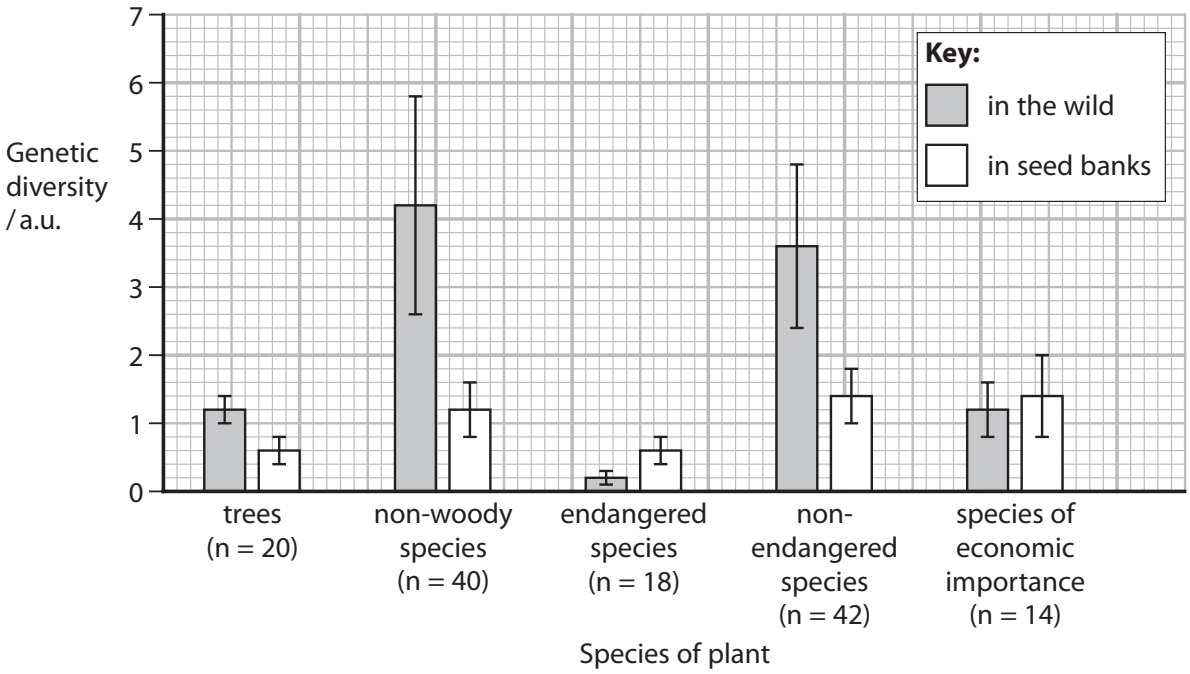
*(b) The scientists measured the mean genetic diversity of species in the wild and the mean genetic diversity of the same species in seed banks.

The species examined included:

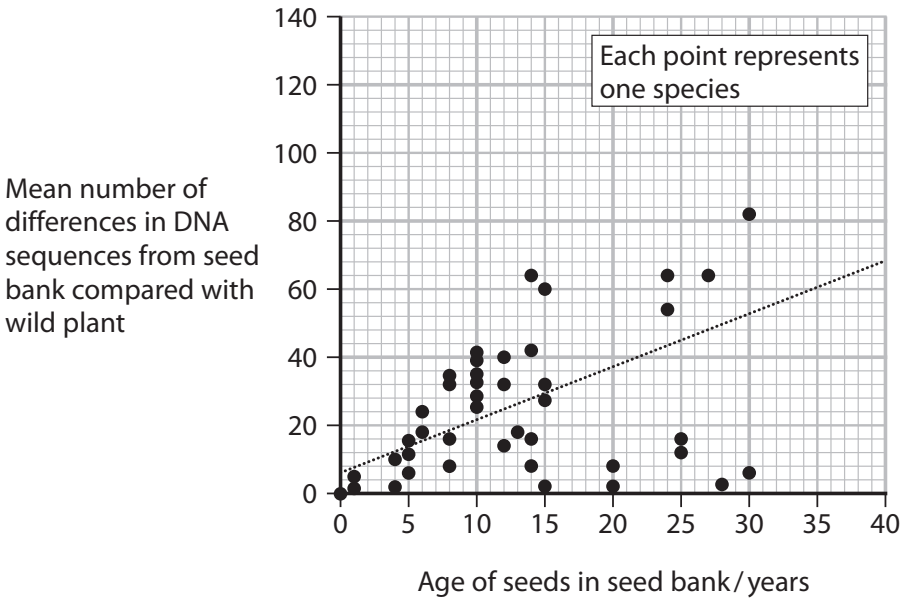
- trees
- non-woody species of plant
- plant species classed as endangered
- plant species classed as not endangered
- plants of economic importance that are harvested by people.

The scientists also measured the mean number of differences in the DNA sequences of the seeds that had been stored for different lengths of time compared with plants in the wild.

The graphs show the results.



Error bars represent +/−1 standard deviation
n = number of different species



Analyse the data to discuss the results of this investigation.

(6)

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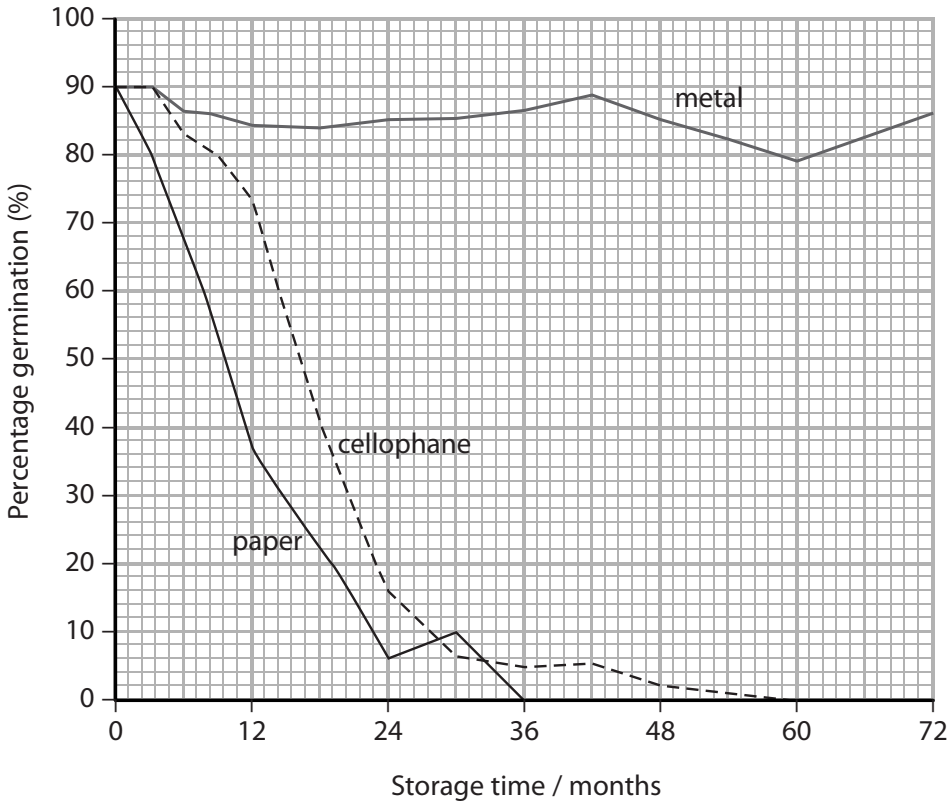
9 Seed banks store seeds for future use. Seeds can be stored for a long time if the seeds are kept dry with a moisture content of less than 8%.

The seeds are stored in closed containers. The percentage germination of the seeds is measured to test their viability during storage.

At the Millennium Seed Bank, the seeds are stored in closed glass containers at 15% relative humidity at a temperature of –20 °C.

The graph shows the percentage germination of seeds kept in three different closed containers: metal, cellophane and paper. They were kept for 72 months at a temperature of –20 °C.



(a) Analyse the data to explain why seeds are stored in glass containers in the Millennium Seed Bank.

(4)

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(b) Each time the seeds are tested for viability, 50 seeds are used.

State why 50 seeds are used.

(1)

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(c) Calculate the rate of change in viability of the seeds stored in a cellophane container for the first two years.

(2)

Answer .....

(d) Seeds from other parts of the world are stored in seed banks.

(i) Explain how the viability test would be different for these seeds from other parts of the world.

(3)

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(ii) Explain why plants grown from these germinating seeds may not flower at the same time of year as they would have done in their country of origin.

(2)

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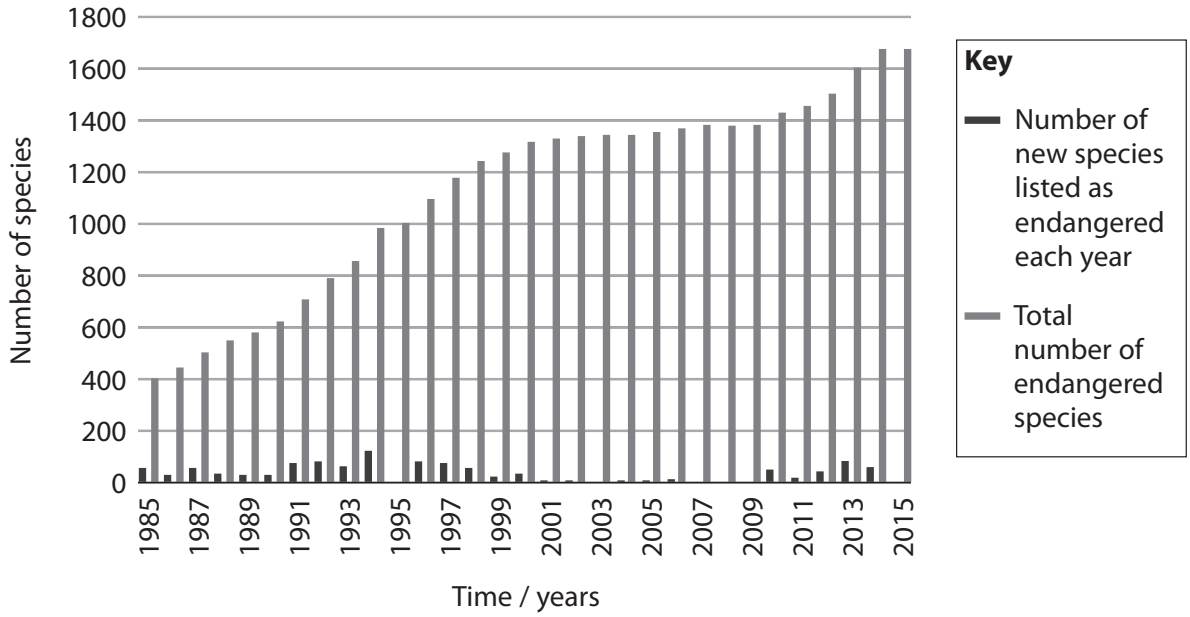
(Total for Question 9 = 12 marks)

6 The graph shows the total number of endangered species and the number of new species listed as endangered from 1985 to 2015.



(a) (i) Calculate the rate of change in the total number of endangered species between 1985 and 2015.

(2)

Answer .....

(ii) Explain how the total number of endangered species and the total number of new species listed as endangered each year have both changed.

(4)

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*(b) A student stated that 'zoos are successful at protecting endangered species from extinction'.

Evaluate the validity of this statement.

(6)

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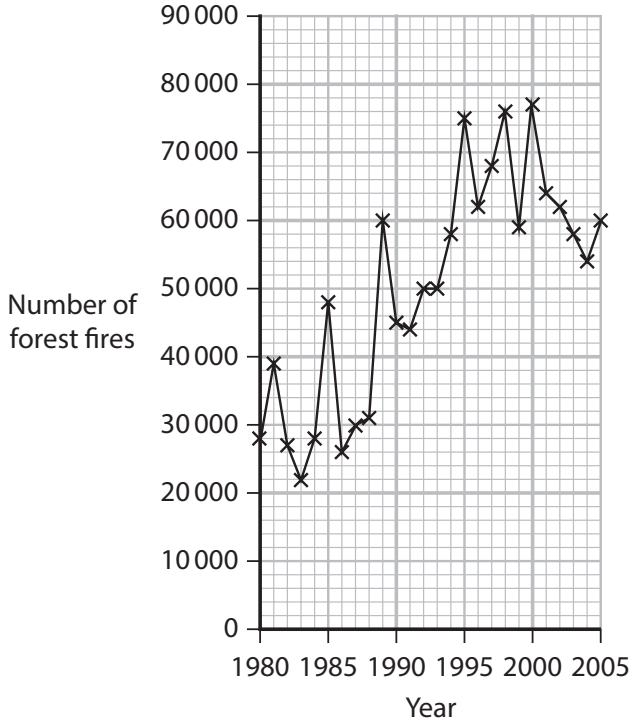
5 Forest fires often occur in areas with old, dry trees.

Graph 1 shows the number of forest fires recorded in Europe from 1980 to 2005.

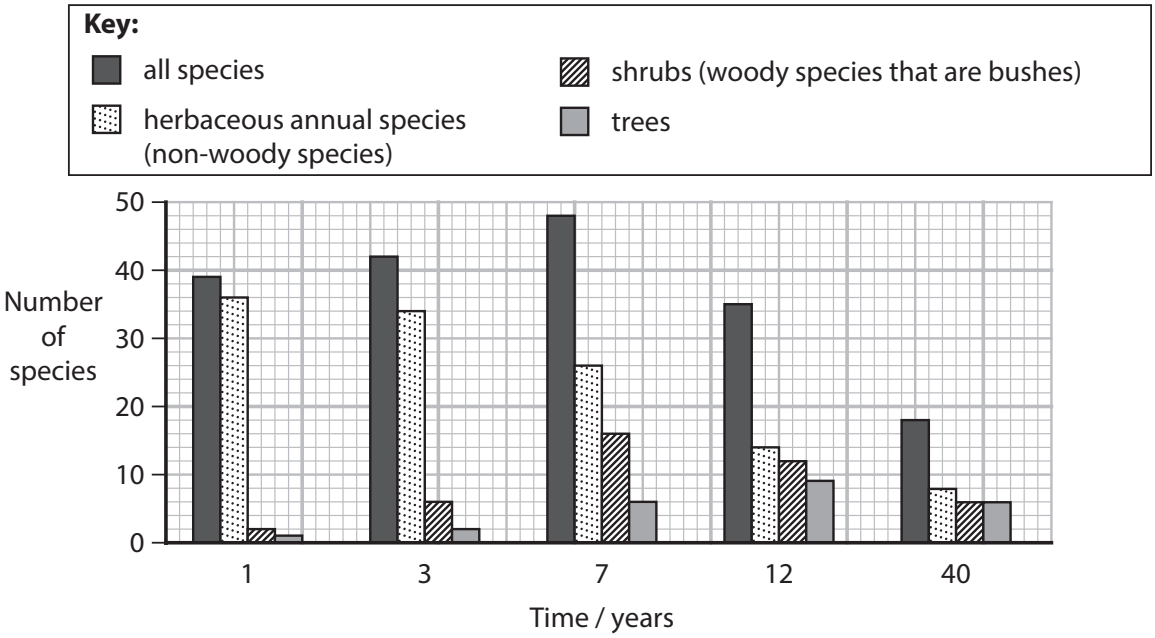
Graph 1



Scientists investigated the changes in plant species for 40 years after a forest fire.

The results are shown in Graph 2.

Graph 2



*(a) Some scientists have stated that the number of forest fires is increasing due to climate change and that measures need to be taken to stop forest fires.

Analyse the data to discuss whether measures to prevent climate change need to be taken to prevent further forest fires.

(6)

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(b) In this investigation, the scientists compared the numbers of different plant species.

The scientists also calculated a diversity index for tree species 40 years after the fire. This index gave a value of 7.33.

The table shows data for an area of forest seven years after the fire.

Tree species	Number of trees
Aleppo pine	45
Silver fir	30
Beech	14
Oak	12
Chestnut	18
Plane	11

(i) Calculate the index of biodiversity (D) for the trees shown in the table for this area of forest.

Use the formula

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

Give your answer to **two decimal places**.

(3)

Answer .....

(ii) State why using the index of diversity is a more valid way of comparing biodiversity of areas than comparing the number of species.

(1)

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(iii) Explain why a high species diversity means that an area is more resistant to environmental changes.

(2)

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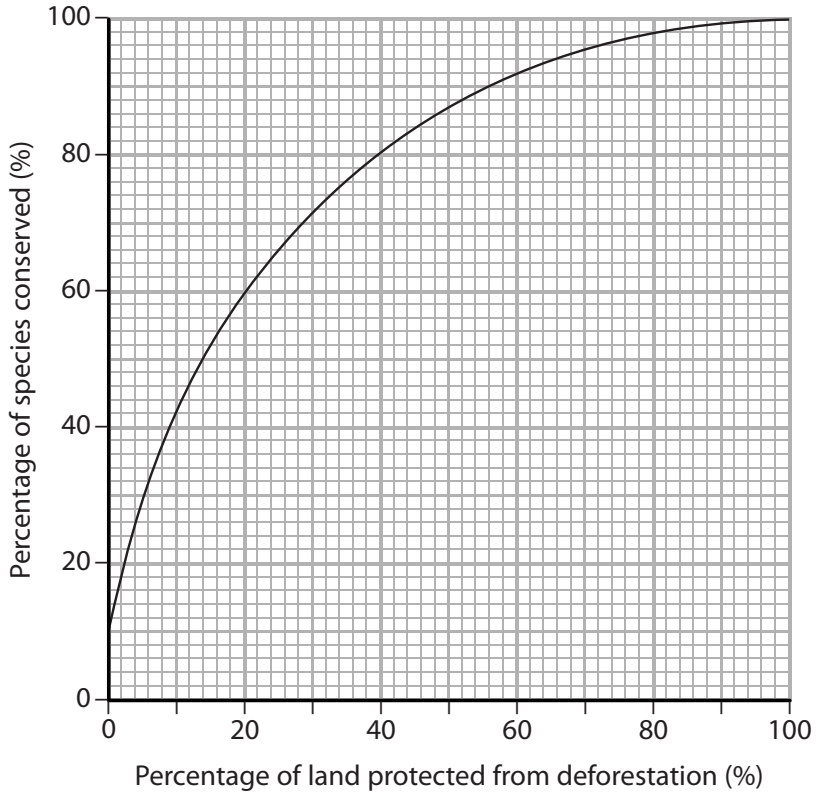
5 The World Wide Fund For Nature (WWF) is the largest conservation organisation in the world.

The WWF recently claimed that 'some 46 000 to 58 000 square miles of forest are lost each year. This is equivalent to 36 football fields every minute'.

This level of deforestation affects biodiversity.

Scientists studied the relationship between protecting land from deforestation and the percentage of species conserved.

The graph shows the results of the study.



(a) Analyse the data in the graph to explain how protection of land affects the percentage of species conserved.

(4)

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(b) The number of species in a forest is one factor that affects biodiversity.

Some scientists use the following formula to calculate biodiversity.

$$D = \frac{N(N-1)}{\Sigma n(n-1)}$$

Describe how scientists could collect the data needed for this formula in order to calculate biodiversity.

(3)

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*(c) Some scientists state that 'all forests should be protected from deforestation'.

Evaluate this statement.

(6)

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8 (a) Explain the difference between biodiversity within a habitat and biodiversity within a species.

(2)

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(b) Biodiversity can be measured by calculating an index of diversity.

The following data were collected from a freshwater pond in England.

Species	Number of individuals (n)
Mayfly nymph	80
Freshwater shrimp	23
Freshwater hoglouse	14
Beetle larvae	9

(i) Calculate the index of diversity (D) for this pond.
Use the formula

(3)

$$D = \frac{N(N-1)}{\Sigma n(n-1)}$$

Answer .....

(ii) A pond in a different area had a lower index of diversity.

Explain how the composition of this second community could have resulted in this lower index of diversity.

(2)

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*(c) Discuss the use of *in-situ* and *ex-situ* methods in the conservation of endangered species.

(6)

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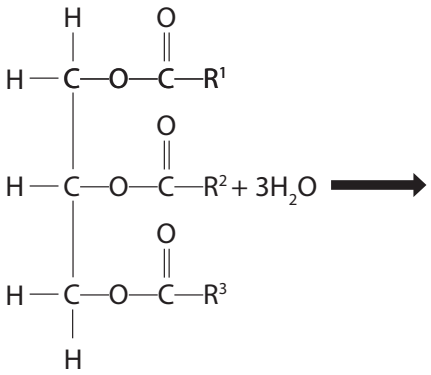
5 Palm plants and cocoa plants are used to produce lipids for the food industry.

Palm oil is produced from palm plants. Cocoa butter is produced from cocoa plants.

(a) Palm oil and cocoa butter are made of triglycerides composed of different fatty acids.

The diagram shows a triglyceride.



Complete the diagram to show the products of hydrolysis of this triglyceride.

(2)

(b) The fatty acid compositions of palm oil and cocoa butter are shown in the table.

Fatty acid	Chemical formula of fatty acid	Percentage of fatty acid found in palm oil and cocoa butter (%)	
		Palm oil	Cocoa butter
palmitic acid	$C_{16}H_{32}O_2$	45	27
oleic acid	$C_{18}H_{34}O_2$	40	31
linoleic acid	$C_{18}H_{32}O_2$	10	3
myristic acid	$C_{14}H_{28}O_2$	1	1
stearic acid	$C_{18}H_{36}O_2$	4	38

(i) How many of the named fatty acids shown in the table are saturated?

(1)

☐ **A** 1

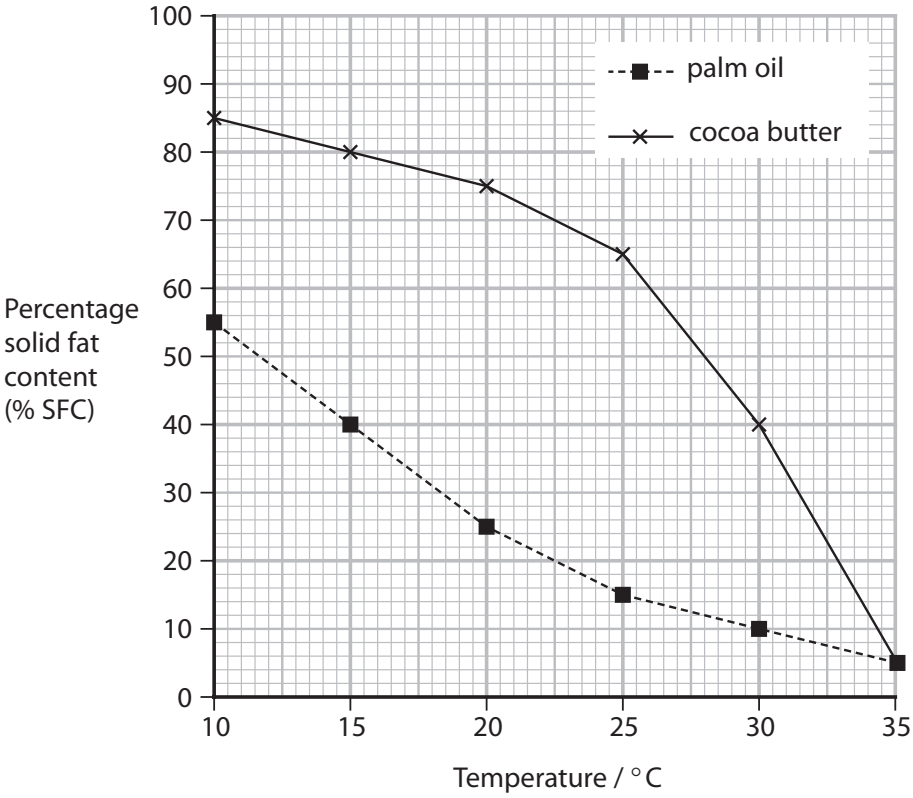
☐ **B** 2

☐ **C** 3

☐ **D** 4

(ii) The percentage solid fat content (% SFC) is a measure of how much of a lipid is solid at different temperatures.

The graph shows the effect of temperature on the % SFC for palm oil and for cocoa butter.



Comment on the effect of temperature on the % SFC of palm oil and of cocoa butter.

(4)

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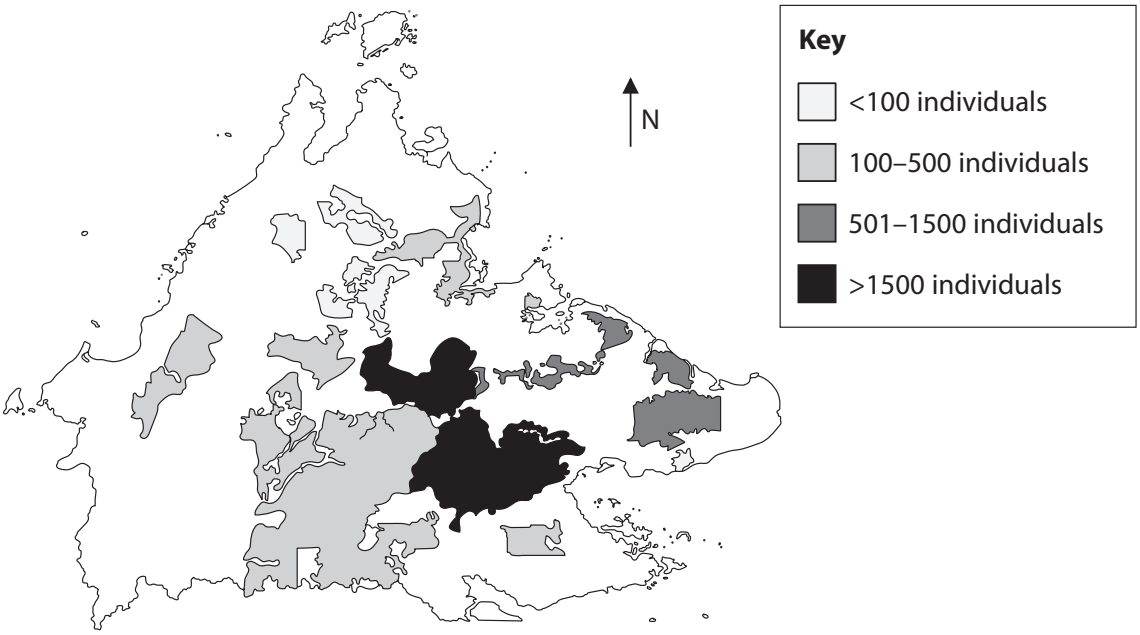
(c) Some forests in Borneo have been cleared to grow these plants.

Orangutans used to live in forests throughout this island but now they are found in small areas of forest.

The map shows the distribution of orangutans in parts of Borneo.



(i) Explain why in areas with low populations of orangutans, many of the orangutans have deformities and health problems.

(2)

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(ii) The Malaysian government is paying local people to create and maintain 'land-bridges' of forest to link areas of forest together.

Explain why these payments will help to develop palm oil production and support conservation of orangutans.

(3)

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(iii) State how treaties such as CITES help conserve orangutans.

(1)

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(Total for Question 5 = 13 marks)

10 Grassland is an important habitat for grazing animals such as cattle.

(a) Fields used for grazing cattle must have a high gross primary productivity.

State what is meant by the term gross primary productivity and include the units in which it is measured.

(2)

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(b) Cattle graze on the plants on grassland.

Describe what happens to the energy in the plants that are not eaten by cattle.

(2)

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*(c) When grazing animals such as cattle, sheep and horses are kept in fields, their faeces are left on the ground, and are known as dung.

The dung is eaten by dung beetles, which in turn are eaten by other animals.

Dung beetles bury dung up to one metre underground in tunnels they have made. This removes the dung from the surface of the field.

A cow can produce over eight tonnes of dung per year.

There are around 60 species of dung beetle in the UK. In 2016, 50% of these were identified as being scarce or threatened.

The photograph shows a dung beetle.

(Source: © Simon Webster/Alamy Stock Photo)

Scientists believe factors causing the decline of dung beetles include:

- farmers using more land to grow crops, and using more land for building and development
- keeping some grazing animals in sheds over the winter, rather than them spending the winter in fields
- fewer habitats for dung beetles, leading to populations of dung beetles becoming isolated and preventing outbreeding
- grazing animals routinely being treated with anti-parasitic drugs that can kill dung beetles.

Some scientists have stated that farming practices need to change to conserve the species of dung beetle, and to maintain biodiversity and the stability of ecosystems.

Discuss the validity of this statement.

(9)

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10 Oceans cover 71% of the Earth's surface. Marine and coastal habitats are thought to contain about one quarter of all species worldwide.

(a) Some parts of the UK coastline have been designated Marine Conservation Zones (MCZ). These are part of a wider network of sites protected by law, called Marine Protected Areas (MPA).

Large parts of the UK coastline and the sea surrounding it are protected in this way. There are more than 370 protected coastal or marine sites around the UK.

The regulations in these areas protect coastal and marine habitats, and the communities and species which live in them, from damage by humans.

This is an example of in-situ conservation.

Comment on the benefits **and** difficulties of in-situ conservation in coastal and marine sites.

(4)

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*(b) Seagrasses are flowering plants that live underwater in coastal habitats.

Seagrass meadows are one of the world's most threatened habitats, but only 26% are within Marine Protected Areas.

In the past, seagrass meadows were common worldwide. Over the last 90 years the area covered by seagrass has declined dramatically, with around 7% being lost each year.

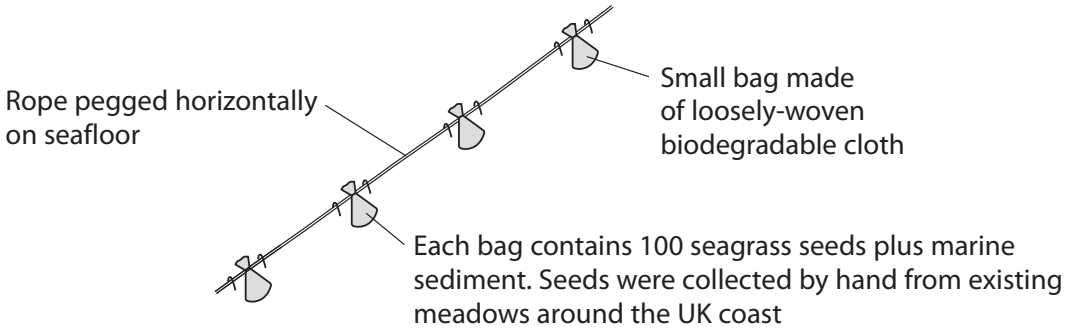
These losses are due to water pollution, damage from fishing, dredging and building ports.

Worldwide, seagrass covers 0.2% of the ocean, but is estimated to be responsible for 10% of its carbon storage. It can store at least 0.5 tonnes of carbon per hectare per year, which is more than a tropical rainforest.

Seagrass meadows protect the coastline from wave erosion. They also provide food and shelter for young fish, including commercially important species like cod.

Around the UK, 90% of seagrass meadows have been lost and only 8 500 hectares remain. A pilot project will plant two hectares of seagrass meadow off the coast of Wales.

Different planting methods have been trialled at different sites. The diagram shows the most successful method, where 4% of seeds germinate after eight months.



Analyse the information to evaluate the importance of seagrass as a habitat, and the importance of this pilot project.

(9)

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3 Organic farming does not use artificial insecticides, herbicides or fertilisers, all of which are used in conventional farming.

Students investigated the effect of organic farming on the species diversity of butterflies.

They compared fields used for growing crops on an organic farm and on a conventional farm.

Butterflies were sampled three times on both farms during July. They were collected by walking around the fields using a sweep net. On each sampling exercise, the butterflies were collected until no more butterflies were seen.

Sampling was only carried out when the temperature exceeded 25 °C and the wind speed was low.

The results are shown in the table.

Species of butterfly	Number of butterflies	
	Organic farm	Conventional
Cabbage white	22	44
Common blue	12	0
Large skipper	4	0
Monarch	3	0
Painted lady	11	0
Peacock	14	5
Red admiral	35	6
Small copper	2	0
Swallowtail	14	4

(a) (i) The index of diversity for the conventional farm is 1.54

Use the formula to calculate the index of diversity for the organic farm.

$$D = \frac{N(N-1)}{\Sigma n(n-1)}$$

N = total number of organisms of all species
n = total number of organisms of a particular species

(2)

Answer .....

(ii) Explain why the organic farm has a higher index of diversity than the conventional farm.

(3)

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(iii) Criticise the method used by the students to obtain these results.

(4)

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(b) Some conventional farms have converted to organic farming.

A further experiment was carried out to investigate the effect on species diversity of how long the farms have used organic methods.

(i) Butterflies and plant species were sampled from a range of farms that had used organic farming methods for different lengths of time.

The number of plant species and the number of butterfly species were recorded.

The results are shown in the table.

Years of organic farming	Number of plant species	Number of butterfly species
0	17	4
1 to 5	38	12
6 to 15	42	14
16 to 25	39	12

Explain how the number of years of organic farming affects the biodiversity of butterfly species.

(3)

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(ii) Creeping thistle is considered to be a weed.

Creeping thistle has a deep root system and takes many years to be completely removed by organic farming methods.

The moth population and the number of creeping thistle plants were counted.

The results are shown in the table.

Years of organic farming	Number of moth species	Number of creeping thistle plants
0	15	10
1 to 5	27	235
6 to 15	20	74
16 to 25	10	14

Explain the changes in the number of moth species.

(2)

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(Total for Question 3 = 14 marks)

10 The Northern elephant seal is a mammal found in the Eastern Pacific Ocean.

In the nineteenth century, Northern elephant seals were hunted and this reduced the population to about 20 seals.

The seals were listed as an Appendix II species when CITES was established in the 1970s.

The population has now recovered to over 100 000 individuals.

The seals in this population have developed health problems, including a high mortality rate for newborn pups, deformities and weak immune systems.

(a) (i) Describe the role of treaties such as CITES in maintaining global biodiversity.

(2)

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(ii) Explain why, although the population of seals has recovered, many of the seals have health problems.

(2)

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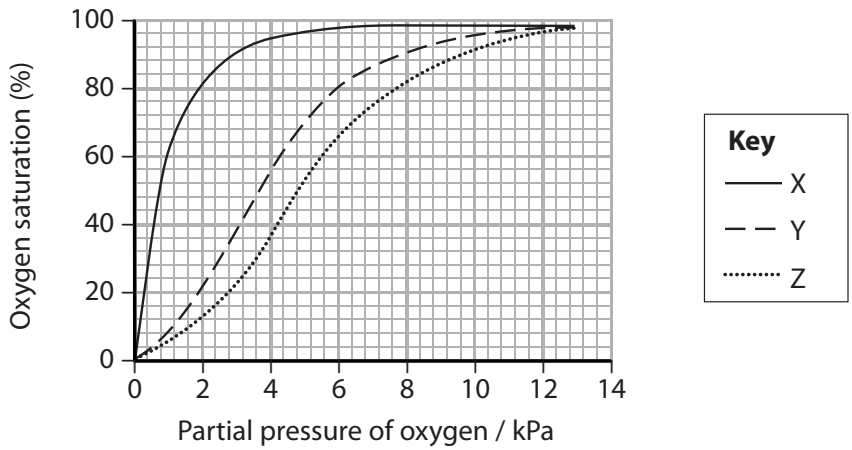
(b) Northern elephant seals have a high concentration of haemoglobin in their blood.

The graph shows the oxygen dissociation curves for myoglobin, adult haemoglobin and fetal haemoglobin.



Which of the rows correctly matches each curve with myoglobin, adult haemoglobin and fetal haemoglobin?

(1)

	Myoglobin	Adult haemoglobin	Fetal haemoglobin
☒ **A**	X	Y	Z
☒ **B**	X	Z	Y
☒ **C**	Y	Z	X
☒ **D**	Z	X	Y

(c) Northern elephant seals are able to dive to great depths and hold their breath for up to two hours.

The tables show data for four diving mammals.

Species	Maximum time holding breath / min	Maximum diving depth / m	Mass of animal / kg
bottlenose dolphin	5	20	200
harbour seal	17	19	24
Weddell seal	82	400	400
Northern elephant seal	119	437	400

Species	Volume of oxygen in body / $cm^3\ kg^{-1}$	Concentration of haemoglobin in blood / $g\ dm^{-3}$	Total blood volume / $cm^3\ kg^{-1}$	Percentage of stored oxygen in different body tissues		
				lungs	blood	muscle
bottlenose dolphin	36	14	71	34	27	39
harbour seal	57	21	132	13	54	33
Weddell seal	87	210	173	5	66	29
Northern elephant seal	97	216	207	4	71	25

(i) Calculate the total mass of haemoglobin in a Northern elephant seal.

(3)

Answer .....

*(ii) Analyse the data to explain how marine mammals are adapted for diving.

(6)

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4 A survey was carried out to compare the biodiversity in different areas of a village.

The photograph shows a children's playing field in this village.

(a) Quadrats placed in the playing field showed predominantly grass with a few dandelion species, ribbed plantains, yarrow and clover. No animal species were observed.

The biodiversity of this playing field was low.

(i) Explain the reasons why the biodiversity of this playing field was low.

(3)

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(ii) The photograph shows a path in a woodland nature reserve near the playing field in this village.

After surveying the playing field, a survey of the woodland reserve was carried out using the following method:

- quadrats were placed at various intervals either side of the path
- plant species were counted in the quadrats
- animal species were counted at regular intervals along the path.

The table shows the results of this survey.

	Species	Number
Plant	Dock	10
	Thistle	10
	Hawthorn	6
	Wild cherry	2
	Hazel	5
	Yarrow	5
Animal	Meadow brown butterfly	2
	Shield bug	4
	Beetle	20
	Honeybee	20
	Dragonfly	4
	Spider	5

Calculate the biodiversity index for this woodland nature reserve.

Use the formula

$$D = \frac{N(N-1)}{\Sigma n(n-1)}$$

(3)

Answer .....

(iii) It was suggested that the biodiversity index calculated from this survey was an underestimate.

Criticise the method used in the survey of the woodland nature reserve.

(6)

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(b) Honeybees are important pollinators of flowers.

Surveys have suggested that butterflies, ladybirds, beetles, flies and dragonflies are also important pollinators of flowers.

A recent report has suggested that a large increase in honeybees kept in towns and cities could affect biodiversity.

Explain how the increase in honeybees in towns and cities could affect biodiversity.

(2)

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9 Gilbert's potoroo is one of the most critically endangered species in the world.

Gilbert's potoroo was thought to be extinct until one was found in 1994.

It is thought that there are only 70 individuals.

The photograph shows a potoroo and its pouched baby feeding on berries.

The map shows the only part of Australia where Gilbert's potoroo is found.

The diet of Gilbert's potoroo is about 90% fungi.

Analysis has shown that the fungal spores are spread in the faeces of the potoroos.

These spores then germinate.

(a) Explain the advantage to the ecosystem of fungal spores being spread by potoroos.

(2)

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(b) In 1994, there were only 20 Gilbert's potoroo individuals, 12 of which were in a captive colony.

A captive breeding programme was set up using:

- four adult females and one young female
- one adult male, two young males and one young male still in its mother's pouch.

(i) Explain why allele frequencies may cause problems in this population of potoroos.

(3)

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(ii) Foxes and feral cats, which are predators of potoroos, were introduced into Australia by settlers.

The photograph shows a feral cat with its prey.

The Australian government is using poisoned sausages in an attempt to kill 2 million feral cats by 2020.

The sausages contain chunks of kangaroo meat combined with chicken fat, herbs, spices and a poison.

The content of the sausages was based on flavours irresistible to cats.

The poison used is produced by the Swan River pea plant that is found in Western Australia. Other Australian plants that contain the poison are: *Acacia*, Wedge Peas and *Nemcia*.

This poison is a natural toxin that biodegrades rapidly and the native wildlife in Australia has evolved natural resistance to it.

A group of 160 000 people in Australia have signed a petition against the plan to poison feral cats.

Discuss whether the plan to poison feral cats is justified.

(9)

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9 Asiatic lions are endangered animals. Some of these lions have been kept in zoos for many years.

The photograph shows a group of Asiatic lions.

(Source: © FELIS IMAGES / NATURE PICTURE LIBRARY / SCIENCE PHOTO)

In 2017, a European zoo stated that 392 lions in captivity had died over a period of 14 years. Of these, 80% were less than one year old.

(a) (i) The population of Asiatic lions in the zoo was initially started by breeding from nine lions.

Explain why many of the next generations of lions died before they were one year old.

(2)

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(ii) Some of the young lions have a condition of the nervous system caused by a recessive allele.

In wild populations of Asiatic lions, this recessive allele has a frequency of 0.02.

In zoo populations of Asiatic lions, the recessive allele has a frequency of 0.30.

Determine the frequency of heterozygous Asiatic lions in **zoo** populations.

Use the Hardy-Weinberg equation

$$p^2 + 2pq + q^2 = 1$$

(2)

Answer .....

(iii) State **two** conditions that must occur for allele frequencies to stay constant over several generations.

(2)

1 .....

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(iv) Describe how CITES helps to maintain populations of Asiatic lions in the wild.

(2)

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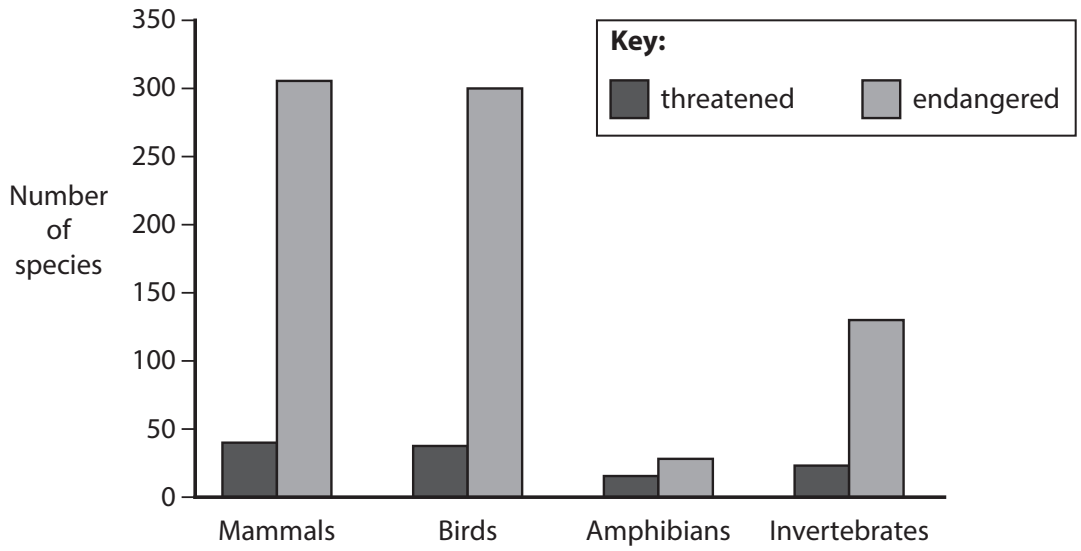
*(b) Zoos keep many species in captivity and also engage in research, ex-situ conservation, and in-situ conservation.

Scientists investigated the roles of zoos in the conservation of different species of mammals, birds, invertebrates, and amphibians.

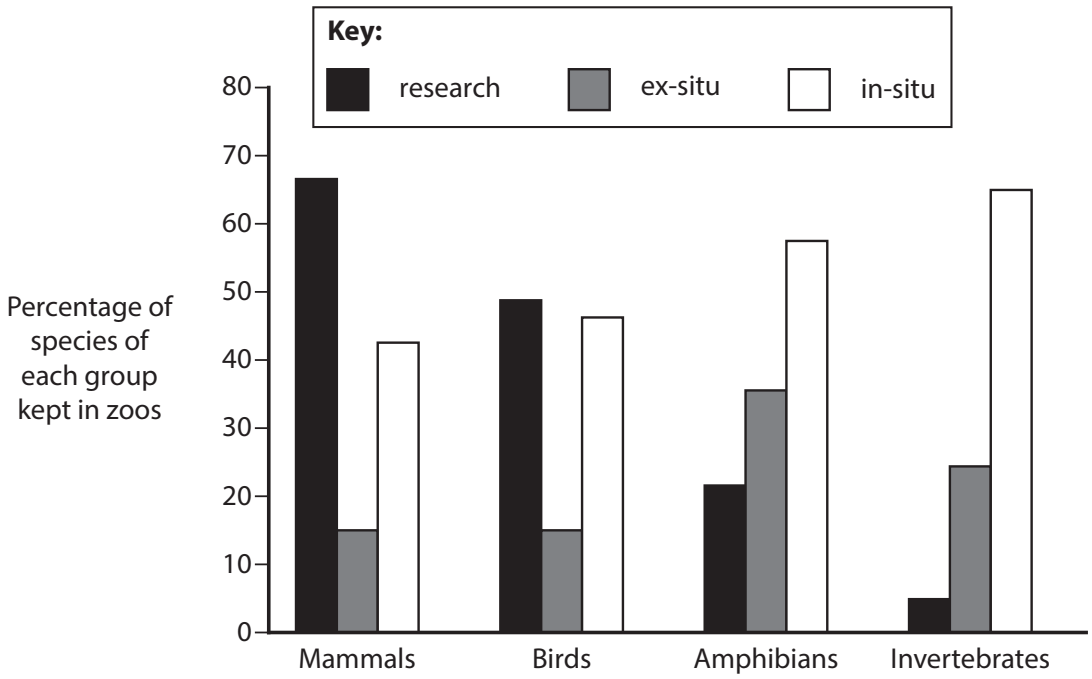
Graph 1 shows the numbers of species of each group that are kept in zoos and listed as being endangered or threatened with becoming endangered.

Graph 2 shows the percentages of species of each group kept in zoos that are used by the zoos for research, for ex-situ conservation, and are overseen for in-situ conservation.

Graph 1



Graph 2



Analyse the data and use your own knowledge to discuss the effectiveness of zoos as centres for the conservation of animals.

(6)

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6 The photograph shows a brown tree snake.

© staticflickr.com

The brown tree snake is found in areas of Indonesia.
This snake eats small mammals, birds and reptiles.

In the 1940s, the brown tree snake was introduced to the Pacific Island of Guam.
The population of this snake is now over two million.

Its introduction has had major effects on bird species in Guam.

The table shows the numbers of individuals of each bird species surveyed in the areas where this snake was present.

Species	1981	1982	1983	1984	1985	1986
Island collared-dove	0	0	3	19	1	0
White-throated ground-dove	1	3	5	5	0	0
Marian fruit-dove	11	19	3	0	0	0
Micronesian kingfisher	29	17	35	26	4	0
Marian crow	28	33	47	36	51	0
Guam flycatcher	6	23	11	0	0	0
Rufous fantail	74	55	43	0	0	0
Micronesian starling	148	159	135	71	7	0
Micronesian honeyeater	31	31	33	2	0	0
Bridled white-eye	108	98	2	0	0	0
Index of diversity (D)	4.6	4.7	4.1	3.5		0.0

(a) (i) Calculate the index of diversity for 1985 using the formula

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

(3)

Answer .....

(ii) Explain why using an index of diversity is a better measure of biodiversity than counting the number of species only.

(2)

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(iii) Comment on the effects of introducing the brown tree snake to Guam.

(4)

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(b) The biodiversity of plant species on Guam has decreased.

(i) Give two reasons why changes in the number of bird species have led to this decrease in biodiversity of plant species.

(2)

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(ii) Scientists are using seed banks to conserve the biodiversity of plants.

Describe how seed banks are used as a method of conservation.

(4)

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9 Biodiversity is monitored by conservationists.

Biodiversity can be calculated using the formula

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

(a) Give the symbol in this formula that represents the total number of organisms of all species.

(1)

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(b) The photograph shows a hedge.

(Source: © 1000 Words/Shutterstock)

Many fields in the UK are separated by hedges.

Conservationists investigated biodiversity in hedges of different ages.

Hedges of different ages were sampled at random and the number of species of woody plants was counted.

The graph shows the results of this investigation.

Analyse the data to explain why conservationists object to the destruction of hedgerows to increase the size of fields.

(4)

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(c) State why random sampling was used in this investigation.

(1)

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(d) The conservationists observed that the plants in older hedges contained more wood than the plants in younger hedges.

Wood consists of xylem tissue.

(i) Give an advantage for older plants of containing more wood.

(1)

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(ii) Describe a method to show that the stem of an older plant contains more wood.

(3)

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(e) A student thought that the age of a plant affects the water potential of its tissue.

The student used potatoes of different ages to test this hypothesis.

Justify each step of a method the student could use to compare the water potential of potato tissue of different ages.

(5)

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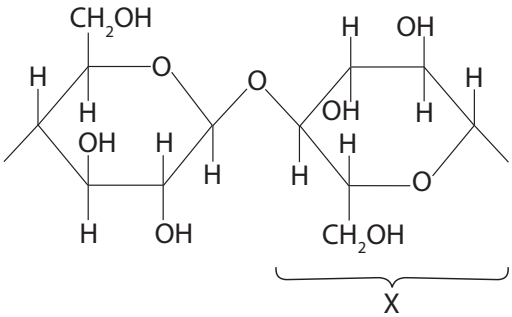
9 In Kenya, an in-situ conservation project has been set up to make paper from elephant dung.

This project aims to help conserve elephant populations, conserve biodiversity and help local communities.

(a) Paper is produced from cellulose molecules present in elephant dung.

The diagram shows part of a cellulose molecule.



(i) Which of the following is the name of the monomer labelled X on the diagram?

(1)

☒ **A** α glucose

☒ **B** β glucose

☒ **C** α ribose

☒ **D** β ribose

(ii) Draw one of the products of the hydrolysis of this part of the cellulose molecule.

(2)

(iii) Explain how the structure of cellulose is adapted for its function in plant cell walls.

(3)

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(b) Elephant conservation often involves the setting up of protected areas to stop poaching. Local people are banned from entering these areas.

This method of elephant conservation sometimes causes conflict with local people, as elephants can trample and eat crops in nearby farmland. Farmers sometimes burn areas of grassland and forest to stop elephants destroying their farmland.

The new paper conservation project encourages local people to make paper from elephant dung they collect from the conservation area. The paper they make is sold at a high price.

Conservationists measured the effect of the new paper project on the index of diversity of the area over two years. They also measured the effect of a protected conservation area where local people were banned from entering on the index of diversity. The results are shown in the table.

Area	Index of diversity	
	At start of project	After two years
Conservation area with paper project	2.8	3.6
Conservation area where local people are banned from entering	2.4	2.2

(i) State why calculating an index of diversity is a better measure of biodiversity than counting the number of different species.

(1)

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(ii) Give two advantages of in-situ conservation of elephants compared with ex-situ conservation of elephants.

(2)

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(iii) Explain the effect of the new paper project on biodiversity compared with the protected area where local people were banned.

(4)

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(c) Describe the limitations of CITES in the conservation of organisms such as elephants.

(2)

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MARK SCHEMES

official Pearson Edexcel mark schemes

Number	Answer	Additional Guidance	Mark
1(a)	An answer that includes the following: • conversion of actual size and correct measured size to same units (1) • correct answer to nearest whole number (1)	Sample calculation Accept 64 000 to 66 000 (for measured size in μm) 6×10^{-4} (for actual size in cm) 6×10^{-3} (for actual size in mm) Accept answers in range **10 667 to 11 000** **Do not allow** units Correct answer with no working gains 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that includes the following: • cell drawn correct shape with clear lines and no {shading / hatching} (1) • {nucleus / vacuole} (1)	Ignore cell wall if drawn **Do not allow** mitochondria **Do not allow** anything smaller eg ribosomes	**(2)**

Question Number	Answer	Additional Guidance	Mark
1(c)(i)	• (presence of) {membrane-bound organelles / named organelle} / nucleus / linear chromosomes / 16 chromosomes / cell wall made of {chitin / mannose} (1)	Accept does not have a nucleoid / Accept does not have a looped {chromosome / DNA} Ignore has a cell wall unqualified	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(c)(ii)	• cell wall not made of cellulose / glycogen granules present / no chloroplasts present / it is single celled / does not have {roots / a stem / leaves} (1)	Accept only what can be seen in the diagram Accept cell wall made of chitin and / or mannose Ignore refs to chlorophyll / photosynthesis Accept not multicellular	**(1)**

(Total for Question 1 = 6 marks)

Question Number	Answer	Mark
1(a)(i)	**The only correct answer is B kingdom** **A** *is not correct because it does not contain the greatest variety of organisms* **C** *is not correct because it does not contain the greatest variety of organisms* **D** *is not correct because it does not contain the greatest variety of organisms*	**(1)**

Question Number	Answer Additional guidance	Mark
1(a)(ii)	**The only correct answer is C family** **A** *is not correct because closely related genera are not grouped in a class* **B** *is not correct because closely related genera are not grouped in a domain* **D** *is not correct because closely related genera are not grouped in an order*	**(1)**

Question Number	Answer	Mark
1(a)(iii)	**The only correct answer is D Protista** **A** *is not correct because archaea is a domain* **B** *is not correct because bacteria is a domain* **C** *is not correct because eukarya is a domain*	**(1)**

Question Number	Answer	Additional guidance	Mark
1(b)(i)	An explanation that makes reference to the following points: • used techniques of molecular phylogeny / such as protein biochemistry (1) • which found similarities and differences between archaea and bacteria (1) • **such as** membrane structure, membrane proteins, membrane bound organelles, (1)	allow bioinformatics **examples of evidence** lipid structure, ribosome, plasmids, operons, antibiotic resistance, chloroplasts	**(3)**

Question Number	Answer	Additional guidance	Mark
1(b)(ii)	• peer reviewed journals / scientific conferences		**(1)**

(Total for Question 1 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)	An explanation that makes reference to the following: • not Bacteria as Archaea do not have a peptidoglycan cell wall (1) • not Eukaryota as these organisms {have 70S ribosomes / do not have a nucleus} (1)	**IGNORE** refs to gram negative and gram positive bacteria prokaryotes **DO NOT ACCEPT** if wrong reason given as well **ACCEPT** do not have 80S ribosome **IGNORE** refs to other membrane-bound organelles **DO NOT ACCEPT** if wrong reason given as well	(2)

Question Number	Answer	Additional Guidance	Mark
2(b)(i)	An answer that makes reference to three of the following: • (two enzymes) because enzymes found in different locations (1) • pH is different / their substrates are found in different locations (1) • (two enzymes) because their substrates are different (1) • therefore their <u>active site</u> will be different {shape / structure} (1) • {similar structure / both are AK enzymes / both are kinases} because both {are transferring phosphate / have similar roles (1)	**IGNORE** incorrect explanations of what the enzymes are doing with ATP and GTP **ACCEPT** enzymes cannot move between mitochondria and cytoplasm **ACCEPT** ATP in cytoplasm and GTP in mitochondria **ACCEPT** because one uses ATP and the other uses GTP	(3)

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	An explanation that makes reference to two of the following: • Archaea {do not have mitochondria / only have cytoplasm} so do not need two enzymes (1) • {pH / temperature} of Archaea different to human's (1) • Archaea's enzymes need to be able to {bind / fit} to {two substrates / both ATP and GTP} (1) • {genetic code / (DNA) base sequence} is different **OR** different primary structure (1)	**ACCEPT** need to form ESCs with different substrates **NB** ref to induced-fit may access this point provided in the context of substrate	(2)

Question Number	Answer	Mark
2(a)	**2(a). The only correct answer is C** ***A*** *is not correct because order goes between class and family* ***B*** *is not correct because order goes between class and family* ***D*** *is not correct because order goes between class and family*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)	An explanation that makes reference to three of the following: • dolphins and (minke) whales are the most closely-related as they evolved from the same {species / (recent) common ancestor} **(1)** • the common ancestor of dolphins and minke whales evolved from the same common ancestor as cows **(1)** • pigs are the most distantly-related because they were the {first / earliest} animals to diverge **(1)** • the more closely-related the animals are the {more similar their DNA will be / fewer mutations} **(1)**	**Accept** an account that talks about branching points or speciation **Accept** because their (shared) common ancestor is furthest away **Accept** converse	**(3)**

Question Number	Answer	Additional Guidance	Mark
2(c)	• total number of dolphin's gene families and number of shared gene families **(1)** • percentage of gene families shared **(1)**	Example of calculation 12 678 and 11 189 = 88.26 / 88.3 / 88 **Accept** ecf if one value incorrect	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(d)	An explanation that makes reference to the following: • because dolphins and killer whales are separate species so should not be able to interbreed to produce fertile {offspring / hybrids} **(1)** • but {Kekaimalu / the offspring from the mating of the whale and dolphin} was fertile **(1)**	**Accept** separate species are not able to interbreed to produce fertile offspring **Accept** but Kekaimalu {reproduced / produced offspring}	**(2)**

Total for Question 2 = 8 MARKS

Number	Answer	Mark
4(a)(i)	**The only correct answer is C** ***A*** *is not correct because cellulose is not found in a bacterial cell* ***B*** *is not correct because cellulose and nucleoli are not found in a bacterial cell* ***D*** is not correct because nucleoli are not found in a bacterial cell	**(1)**

Question Number	Answer	Mark
4(a)(ii)	**The only correct answer is C** ***A*** *is not correct because Ebola contains RNA* ***B*** *is not correct because HIV contains RNA* ***D*** *is not correct because tobacco mosaic virus contains RNA*	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(a)(iii)	An explanation that makes reference to the following: • the resolution is higher / better (1) • because wavelength of electrons is short(er) (1)	 **ACCEPT** converse **ACCEPT** smaller wavelength	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	An explanation that makes reference to three of the following: • each domain has unique characteristics (1) • Archaea and Eukarya share three characteristics (1) • Archaea and Eukarya are more closely related / have a more recent common ancestor (1) • differences in {membrane lipids / ribosome size} evolved after Archaea and Eukarya split (1)	 **ACCEPT** Archaea and Eukarya share more characteristics / share no rRNA loop, no antibiotic sensitivity and methionine **ACCEPT** branched carbon chains / ether linkage / 80 S	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	• peer review / (scientific) paper / (scientific) journal / (scientific) conference		**(1)**

Question Number	Answer	Additional Guidance	Mark

Question Number	Answer	Mark
3(a)	**The only correct answer is** C smallest fragment of DNA that travelled the fastest ***A*** *is not correct because it is not the largest fragment of DNA* ***B*** *is not correct because it is not the largest fragment of DNA* ***D*** *is not correct because smallest fragment of DNA does not travel the slowest*	**(1)**

Question Number	Answer	Additional guidance	Mark
3(b)	An explanation that makes reference to three of the following points: • species C (is the most closely related) (1) • as the bands of DNA on the gel most closely match / align with / same pattern (1) • species C has 5 bands in same location (1) • species B has 2 bands and species D has 3 bands (1)	allow converse for least related	**(3)**

Question Number	Answer	Additional guidance	Mark
3(c)	A description that makes reference to **four** of the following: • using information about similar morphology / anatomy (1) • using information about reproduction such as the fertility of hybrids / mate recognition and behaviour (1) • using information about the similarity in proteins / molecular phylogeny (1) • looking at information about ecological niche and where species are found (1) • use of bioinformatics / sequence DNA / sequence amino acid/ use genetic barcodes (1)	allow reference to sexual dimorphism noting that some species male and female have very different morphology allow look up in genetic databases	**(4)**

(Total for Question 3 = 8 marks)

Question Number	Answer	Mark
4(a)(i)	**The only correct answer is A Archaea** ***B*** *is not correct because fungi is a kingdom* ***C*** *is not correct because Insecta is a class* ***D*** *is not correct because plantae is a kingdom*	**(1)**

Question Number	Answer	Mark
4(a)(ii)	**The only correct answer is B bacteria** ***A*** *is not correct because animalia are eukaryotes* ***C*** *is not correct because insects are eukaryotes* ***D*** *is not correct because mammals are eukaryotes*	**(1)**

Question Number	Answer	Mark
4(a)(iii)	**The only correct answer is A domain kingdom phylum class order family genus species** ***B*** *is not correct because the order is incorrect* ***C*** *is not correct because the order is incorrect* ***D*** *is not correct because the order is incorrect*	**(1)**

Question Number	Answer	Mark
4(b)	An answer that refers to two of the following • results / data shared with other scientists / published in journal / attend conferences / (1) • that work in same area / field are experts (1) • who confirm / agree with their conclusions / findings (1)	**(2)**

Question Number	Answer	Additional guidance	Mark
4(c)	An explanation that includes three of following **Advantages** • new reproductive technologies / breeding programs can maximize the probability of reproductive success / prevent inbreeding (1) • can protect species from poaching / predation so numbers can recover / reintroduce animals back into wild / prevent extinction (1) • educate and raise awareness / raise funds for conservation work (1) **Disadvantages** • can lead to abnormal behaviours / adaptations to captivity / stereotypy (1) • so prevents successful reintroduction (1) • reduces biodiversity of natural habitat / affect food chains in habitat (1)	At least one advantage and one disadvantage	**(3)**

(Total for Question 4 = 8 marks)

Question Number	Answer	Mark
6 (a) (i)	The only correct answer is C *A is incorrect as Mammalia is not a family* *B is incorrect as Mammalia is not a family* *D is incorrect as Mammalia is not an order*	**1**

Question Number	Answer	Additional guidance	Mark
6(a)(ii)	• gel electrophoresis / {DNA / base} sequencing / bioinformatics / protein sequencing / morphology / **molecular** phylogeny / anatomical features (1)	**Allow** amino acid sequences of proteins **Allow** DNA hybridisation **Allow** immunological comparison	**1**

Question Number	Answer	Additional guidance	Mark
6(b)(i)	An answer that makes reference to the following: • 34 (**3 marks**) **For one mark each, allow:** • 0.94 (**1 mark**) • 0.06 (**1 mark**)	**Allow** 33 (**3 marks**) **Allow two marks only** for 0.1128 / 11.28(%) / 0.113 / 11.3 (%) **Allow** 0.939(85) **Allow** 0.060(15) **Example of calculation** q^2 = 265 /300 = 0.883 q = 0.93985… p = 1- 0.9395 = 0.0601 2pq = 2 x 0.9395 x 0.0601 = 0.1129279 so, 0.1129279 x 300 = 33.87 **Correct answer with no working gains full marks.**	**3**

Question Number	Answer	Additional guidance	Mark
6(b)(ii)	An explanation that makes reference to the following: • resistant (rats) {survive / breed / produce offspring} (1) • (resistant rats) pass on the **allele** (to offspring) (1)	**Allow** non-resistant rats {die / do not breed / do not produce offspring}	**2**

Question Number	Answer	Additional guidance	Mark
6(b)(iii)	An explanation that makes reference to two of the following: • {heterozygotes / W^RW^N} survive (better) / {heterozygotes / W^RW^N} have advantage (1) • as W^RW^N do not need extra vitamin K / W^RW^R die as need more vitamin K (1) • {heterozygotes / W^RW^N} pass on W^N allele / {heterozygotes / W^RW^N} produce W^NW^N offspring (1)	**Allow** carriers **Allow** W^RW^R rats need more vitamin K **Allow** carriers	**2**

(Total for Question 6 = 9 marks)

Question Number	Answer	Additional guidance	Mark
6(a)	An explanation that includes three of the following: • because it does not allow for species with sexual dimorphism (1) • does not consider organisms in living different areas that cannot attempt to interbreed (1) • some species can produce hybrid offspring / plant species which can be fertile (1) • some species reproduce asexually (1)	allow examples	**(3)**

Question Number	Answer	Mark
6(b)	**The only correct answer is D smaller fragments travel further** ***A*** *is not correct because all fragments do not travel the same distance* ***B*** *is not correct because larger fragments do not travel faster* ***C*** *is not correct because larger fragments do not travel further*	**(1)**

Question Number	Answer	Additional guidance	Mark
6(c)(i)	An answer that includes four of the following points: • unknown species has 5 bands of DNA none of other species has 5 bands / has bands that don't match (1) • so is new species (1) • 4 / most bands are in same position as species C (so most closely related to species C) (1) • 3 bands in common with D (so next most related) / 2 bands in common with A (1) • least bands (only 1 band / no bands) in common with B (so least related) (1)	must indicate so is closely / less closely /less related once	**(4)**

Question Number	Answer	Mark
6(c)(ii)	A description that includes two of the following points: • examine protein biochemistry / proteomics/ (as similar species will have similar proteins coded for by similar DNA / genes) (1) • bioinformatics / DNA barcodes / CBOL (Consortium for the Barcode of Life) (1) • DNA sequencing / DNA profiling / molecular phylogeny (1) • examine ecology niche (to see if similar) (1) • look at morphology / anatomy / histology / structures (1) • examine shared evolutionary relationships (to see if evolved from common ancestor) (1)	**(2)**

(Total for Question 6 = 10 marks)

swer	Additional Guidance	Mar
		(1)

swer	Additional Guidance	Mar
	= 10(%)	(1)

swer	Additional Guidance	Mar
e to the following: ntages e	<u>Example of Calculation</u> ECF from part (i) 100% - 10 % = 90% 1.3 – 0.13 = 1.17 (90 ÷ 100) x 1.3 = 1.2 **cm**^{3} ALLOW 1.17 **cm**^{3} no units or incorrect units gains ONE mark only correct response with no working gains full marks	(2)

	Additional Guidance	Mark
karya malia rdata nmalia oscidea antidae ***odonta*** ***icana***	ACCEPT Eukaryote / Eukaryota Upper case for *Loxodonta* Lower case for *africana*	(2)

	Additional Guidance	Mark
e of the following: (1) eed together / (1)	ACCEPT similar trunk / tusks IGNORE colour / size	(1)

	Additional Guidance	Mark
e following: erences / peer (1) sts repeating the		(1)

ditional Guidance	Mar
converse emoglobin does not bind :ightly when cold / in binds to oxygen more an elephants) when cold	(3)

dditional Guidance	Mark
:EPT -disjunction / :ription of non- unction	(2)

	Additional Guidance	Mar
	IGNORE allopatric	(3)

	Additional Guidanc
g / difficult ng (1)	**ACCEPT** ring species or s species

Answer
: *order*
: *order*
t order

Answer	Additional Guidance
to four of the following:	
hology / physical characteristics} (1)	
, profiling / DNA sequencing / lar phylogeny / bioinformatics} (1)	
species and produce fertile offspring (1)	**ACCEPT** converse

	Additional Guidance	Mar
l)		
l)		
l)	ACCEPT reduce gene flow / change in allele frequency IGNORE references to not breeding once they have become a new species	
l)		
l)		(4)

	litional Guidance	Mark
	o longer geographically tigers from different ıs breed	(2)

ect geographic isolation ore no mating ect allopatric	(4)

	(4)

Question Number	Answer	Additional guidance	Mark
8(a)	• 13.25 - 12.3 =0.95	allow 0.95 to 1.05	**(1)**

Question Number	Answer	Additional guidance	Mark
8(b)(i)	an answer that includes one of • fertility of males and viability in eggs have a similar temperature range • at low and high temperature eggs are not viable and males are infertile	eggs are viable at same temperature that males are fertile	**(1)**

Question Number	Indicative content
8(b)(ii)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Temp** • viability temperatures are always more extreme than fertility **Obs** • As you can survive but not be able to breed **Conc** Low temp range • *D.melanogaster* cannot survive below 10 °C **and** *D. simulans* cannot survive below 10 °C **Obs** • *D.melanogaster* cannot breed below 12 °C **and** *D. simulans* cannot breed below 11 °C **Obs** High temp • *D.melanogaster* cannot survive above 32 °C **and** *D. simulans* cannot survive above 31 °C **Obs** • *D.melanogaster* cannot breed above 30 °C **and** *D. simulans* cannot breed above 28 °C **Obs** • But very similar temperature ranges *D.melanogaster* 12-30 °C *and D.simulans* 11-28 °C / **Conc** • Therefore expect to find them in similar locations **Conc**

	Courtship song *D.melanogaster* has shorter pulse interval / *D.simulans* has longer pulse interval **obs** *D.melanogaster* has shorter pulse duration / *D.simulans* has longer pulse duration **obs** differences in courtship song unqualified = one **obs** Species differences in courtship song so females only respond to males of correct species **Conc** Therefore behavioural isolation / causes reproductive isolation **Conc** speciation is sympatric **Conc**

Level	Mark	Descriptor
	0	No awardable content
1	1-2	The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. ***Gives one observation about temp or courtship =1*** ***Gives one observation and explains one conclusion from temp or courtship or gives two observations from temp or courtship = 2***
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.

	Additional Guidance	Ma
lowing: hromosomes (1) .ta formation}	**Accept** correct descriptions of crossing over between homologous chromosomes	(

	Additional Guidance	Ma
ving:	**Accept** alleles in different order e.g. c^hC	(1

	Additional Guidance	Ma
ving: $^{h}c^h$ (1) .)	**Accept** all mps from Punnett squares **Accept** any clear indication that $c^{ch}c^h$ × $c^{ch}c^h$ are crossed	(

	Additional Guidance	Mark
	Accept change gene pool **Accept** converse **Accept** alleles for phenotypes **Do not accept** genes **Accept** converse **Accept** alleles for phenotypes **Do not accept** genes **Accept** clear labelled diagrams	**(3)**

Number	Answer	Additional Guidance	Mark
6(a)	An explanation that includes four of the following: • collection acts as a selection pressure (1) • (random) mutation (in gene) for pigment / colour (1) • greyish brown plants are less likely to be {collected / found} as harder to see (1) • more likely to reproduce, passing on new **allele** (1) • **allele** frequency increases (1)	Accept collection of plants results in natural selection Accept genetic variation for colour exists (in population) Accept greyish brown plants {better camouflaged / blend in} so not picked Accept converse for brightly coloured plants Accept more likely to pass on allele to offspring Accept converse for brightly coloured plants Accept allele increases in gene pool Accept converse for brightly coloured plants	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	A description that includes four of the following: • obtain DNA (from the two types of plants) (1) • use of {restriction enzymes / endonuclease} to cut DNA into fragments (1) • {DNA / fragments} (loaded) on (agarose) gel with {current passed through / voltage or potential difference applied} (1) • fragments (of DNA) are separated (1) • {same / similar} (banding) pattern suggests they are the same species (1)	Accept use of PCR to amplify DNA Accept use of {taq / DNA} polymerase to sequence DNA Accept movement of (negatively charged) DNA moves to positive electrode Accept description / diagram of banding pattern Accept shorter fragments travel further Accept converse Accept {same / similar} sequence suggests they are the same species	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that includes two of the following: • (if leaf is green it contains) chlorophyll / photosynthetic pigments (1) • so more light absorbed for photosynthesis (1) • so more glucose produced for growth (1) **OR** • (if flower is brightly coloured) it attracts {pollinators / insects} (1) • so (more likely to) reproduce (successfully) (1) • to produce seeds / pass trait on (1)	Accept more wavelengths of light absorbed for photosynthesis Accept more light absorbed leads to higher rate of photosynthesis Accept more GALP / TP / GP for growth Accept so increased genetic variation (as less self-pollination) Accept asexual reproduction (through bulb) still possible if pollination does not occur	**(2)**

Total for Question 6 = 10 marks

Question Number	Answer	Additional Guidance	Mark
4(a)	• sympatric in same (geographical) areas allopatric in different (geographical) areas (1)	**Allow** isolation/separation/barriers instead of area eg geographical isolation for allopatric	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(b)	An explanation that includes three of the following: • mutation causes variation in courtship song (1) • louder song / more distinct song / different song / attracts more female crickets (of the same species) (1) • these crickets more likely to mate successfully (1) • pass on alleles coding for courtship song onto offspring (1)	**Allow** reproduce / breed	**(3)**

Question Number	Indicative content
4(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Overall statements** • *G texensis* **court more overall** • Both species court their own species more than an other species regardless of location **Reference to male courtship behaviour of** *G texensis* **v** *G rubens* with females of same species • *G texensis* males court more in all conditions than *G rubens* • *G texensis* males court females of same species from different location more than from same location • *G rubens* males court females of same species from same location more than from different location **Reference to male courtship behaviour of** *G texensis* **v** *G rubens* with females of different species • *G texensis* males court more • *G rubens* males court females of different species from same location (slightly) more than from different location • *G texensis* males court females of different species from same location and from different location equally **Limitations of evidence** • Role of female not considered • Role of courtship song not considered • no consideration of other behavioral factors • no consideration of chemical / visual / factors • no idea of sample size **Links to speciation** • Inconsistent difference in species between sympatric and allopatric populations suggests other mechanisms involved in speciation • *G rubens* males less likely to court different species • *G texensis* could be allopatric • *G rubens* could be sympatric

Level	Mark	Descriptor
	0	No awardable content
1	1-2	The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. ***Makes reference to one difference between courting (same and different species or location or*** *G texensis* ***vs*** *G rubens* *)* ***=1*** ***Makes reference to two differences between locations = 2***
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. ***Makes reference to three differences in behaviour =3*** ***Makes reference to three differences in behaviour and includes one limitation =4***
3	5-6	An explanation is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured. ***Makes reference to three differences in behaviour and includes one limitation and one link to speciation = 5*** ***Makes reference to three differences in behaviour and includes two limitations <u>and</u> one link to speciation =6***

(Total for Question 4 = 10 marks)

Number	Answer	Mark
4(a)	**The only correct answer is C phylum** ***A*** *is not correct because it is not the largest group* ***B*** *is not correct because it is not the largest group* ***D*** *is not correct because it is not the largest group*	**(1)**

Question Number	Answer	Mark
4(b)	**The only correct answer is D organisms produce many more offspring than survive** ***A*** *is not correct because all organisms do not have enough resources to survive* ***B*** *is not correct because individuals in the same population do not show little variation* ***C*** *is not correct because individuals do not inherit acquired characteristics*	**(1)**

Question Number	Answer	Mark
4(c)	**The only correct answer is B** produce fertile offspring ***A*** *is not correct because same species do not produce hybrid offspring* ***C*** *is not correct because same species do not always live in same location* ***D*** *is not correct because same species do not have no genetic variation*	**(1)**

Question Number	Answer	Mark
4(d)	**The only correct answer is A DNA** ***B*** *is not correct because lipids are not used in classification* ***C*** *is not correct because polysaccharides are not used in classification* ***D*** *is not correct because vitamins are not used in classification*	**(1)**

Question Number	Answer	Additional Guidance	Mark
4 (e)(i)	An explanation that makes reference to four of the following points: • some head lice are resistant to one insecticide (1) • due to a mutation (1) • these resistant head lice survive and reproduce (1) • pass on {allele / gene} for resistance to offspring (1) • resulting in an increase in allele frequency in population (1)	 IGNORE reference to **immune** ALLOW not killed and reproduce not just pass on resistance	**(4)**

Question Number	Answer	Additional Guidance	Mark
4 (e)(ii)	An explanation that makes reference to the following points: • use an insecticide that has not been used before / different insecticide (1) • so no {resistance / selection pressure} (1) • insecticide regularly changed so no resistance develops to any one type (1)	IGNORE immune	**(3)**

(Total for Question 4 = 11 marks)

Number	Answer	Additional Guidance	Mark
6(a)	An explanation that makes reference to three of the following: • genetic variation / mutation (1) • some organisms are better adapted so survive (1) • reproduce / have offspring (1) • therefore {alleles / genes} passed on (1)	 **ACCEPT** converse **ACCEPT** converse **ACCEPT** converse	(3)

Question Number	Answer	Mark
6(b)(i)	**The only correct answer is A** ***B*** *is not correct because litter size is not a behavioural adaptation* ***C*** *is not correct because number of eggs is not a behavioural adaptation* ***D*** *is not correct because pollen production is not a behavioural adaptation*	(1)

Question Number	Answer	Mark
6(b)(ii)	**The only correct answer is C** ***A*** *is not correct because an alarm call is not an anatomical adaptation* ***B*** *is not correct because dominance behaviour is not an anatomical adaptation* ***D*** *is not correct because water potential is not an anatomical adaptation*	(1)

Question Number	Answer	Mark
6(b)(iii)	**The only correct answer is B** ***A*** *is not correct because number of stomata is not a physiological adaptation* ***C*** *is not correct because reduction of leaves is not a physiological adaptation* ***D*** *is not correct because swimming upstream is not a physiological adaptation*	(1)

Question Number	Answer	Mark
6(c)(i)	**The only correct answer is D** ***A*** *is not correct because anatomical differences can exist within species* ***B*** *is not correct because behavioural differences can exist within species* ***C*** *is not correct because genetic differences can exist within species*	(1)

Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	• peer review / (scientific) paper / (scientific) journal / (scientific) conference		(1)

Question Number	Answer	Additional Guidance	Mark
6(d)	An answer that makes reference to four of the following: Similarities • reproductive isolation (1) • one original population / from existing species / have a common ancestor (1) • absence of gene flow / genetic differences accumulate (1) Differences • allopatric requires geographic isolation / sympatric in same geographic area (1) • sympatric caused by different food / behavioural / anatomical / physiological / seasonal / temporal isolation (1) • sympatric results from ploidy (1)	**ACCEPT** no longer mate **ACCEPT** barriers to mating **ACCEPT** example e.g. river **ACCEPT** example e.g. apple maggot fly	**(4)**

Number	Answer	Additional Guidance	Mark
4(a)(i)	D sympatric speciation A is incorrect because allopatric speciation requires geographical separation B is incorrect because genetic speciation is the wrong term C is incorrect because stabilising selection is the wrong term		1

Question Number	Answer	Additional Guidance	Mark
4 (a)(ii)	*An answer that makes reference to:* • have not seen if they can breed and produce fertile offspring with modern mosquitoes (1)		1

Question Number	Answer	Additional Guidance	Mark1
4(a)(iii)	*An answer that makes reference to:* • peer review / published in journals / conferences (1)		1

Question Number	Answer	Additional Guidance	Mark
4(a)(iv)	• Phylum and class (1) • Prisoculex and burmanicus (1)		2

Question Number	Answer	Additional Guidance	Mark
4 (b)(i)	A calculation that makes reference to: • correct calculation to find q (1) • correct calculation to find p (1) • correct calculation to find 2pq and number of mosquitoes (1)	q = 0.899… **Allow** any dp p = 0.101… **Allow** any dp **Allow** ecf for mp2 and mp3 1183 = three marks Correct answer with no working gains full marks	3

Question Number	Answer	Additional Guidance	Mark
4 (b)(ii)	An explanation that makes reference to four of the following: • The frequency of the resistance allele increased in 2015 (1) • because the (resistant) acetylcholinesterase enzyme is not affected by the pesticide / enzyme still works (1) • acetylcholine is still broken down in synapses (1) • the mosquitoes survive and breed (1) • the resistance allele carries a cost as it is reduced when no pesticide is used / after 2015 (1)	**Allow** Number of resistant mosquitoes increases in 2015 **Allow** converse **Allow** converse **Allow** converse **Allow** resistant mosquitoes are at a selective advantage **Allow** lost by genetic drift / non-resistant mosquitoes out compete resistant ones after pesticide use stops **Allow** no selective pressure to retain the resistant allele	4

Question Number	Answer	Mark
8(a)(i)	**The only correct answer is** **B Chordata** A is not correct as Animalia is not a phylum P C is not correct as Eukarya is not a phylum D is not correct as Vertebrata is not a phylum	**(1)**

Question Number	Answer	Mark
8(a)(ii)	**The only correct answer is** ***C*** *Ptilonorhynchus* A is not correct as aves is not a genus B is not correct as bower is not a genus D is not correct as *violaceus* is not a genus	**(1)**

Question Number	Answer	Mark
8(b)(i)	An description that makes reference to the following points : • enables female to judge fitness of male bird (1) • ensures that correct sex / female is courted / mated (1) • ensures that the correct species is courted / mated (1)	**(2)**

Question Number	Answer	Additional guidance	Mark
8(b)(ii)	An explanation makes reference to **four** of the following: • (variation in) bower building caused by mutation (1) • males / birds that build (larger bower) attract (more) females / birds that build (more colourful) bower attract (more) females (1) • so more likely to mate / reproduce (1) • therefore pass on <u>alleles / genes</u> (to offspring) (1) • females who mate with successful bower birds more likely to produce offspring (1)	allow produce offspring	**(4)**

Question Number	Answer	Additional guidance	Mark
8(b)(iii)	An answer that makes reference to **four** of the following: • change the colour of feathers or objects (1) • control size / shape / location of bower / size or shape of objects / time of day / season (1) • control presence / absence of male / use same male / use model male bird (1) • count how many female birds visit bower (1) • in stated time (1) • repeat in different areas / repeat with different females (1)	allow idea of females choosing from selection of bowers	**(4)**

(Total for question 8 = 12 marks)

7(a) (i)	• only one copy (of this allele) is required to affect the phenotype (1)	**Accept** (allele that is) always expressed / expressed in heterozygotes	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	An explanation that makes reference to two of the following: • there are two main peaks as there are only two different alleles (that are not codominant) (1) • environment affects the colour of the feathers (as there are intermediates) / (intermediates are due to) subjective scoring (1) • grey owls have a selective / survival advantage (1)	**Accept** grey peak are homozygous (recessive) owls and brown peak, owls have a dominant allele **Accept** named environmental factors e.g. diet **Accept** converse **Accept** grey survive better due to camouflage	**(2)**

Question Number	Answer	Additional Guidance	Mark
7 (a)(iii)	• correct calculation of q (1) • correct calculation of p (1) • correct calculation of number of heterozygotes (1)	Example calculation 0.84 (accept any number of dp) 0.16 (accept any number of dp) 33 (**Accept** 32) Correct answer with no working gains full marks	**(3)**

Question Number	Indicative content
7 (b)*	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • with increasing snow depth, there is higher survival of grey owls / fewer brown owls survive / more grey owls D • snow depth has decreased over time D • the percentage of brown owls has increased over time / percentage of grey owls has decreased D For • with less snow, more ground is visible / uncovered / more twigs and trees visible E • with less snow, grey owls more obvious (to predators / prey) / less camouflaged E • with less snow, natural selection would favour brown owls / more brown (advantageous) alleles passed on / fewer grey alleles passed on / brown owls outcompete grey owls E • enhanced greenhouse effect due to carbon dioxide emissions reflecting radiation back / absorbing radiation (causing melting) E Against • no direct measure of greenhouse gas / temperature / fossil fuel emissions A • graphs show correlations not causal links A • data for owl survival with snow depth is scattered / gaps in data / weak correlation A • data for mean snow depth has many outliers / anomalies / not all points are around line / data is scattered A • other factors (named factors) could be affecting the owl population A • reduced snow may not be due to greenhouse gas release A

Level 0	Marks	No awardable content
Level 1	1-2 (1-3)	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made . **1 mark : any 1 from D, E, A** **2 marks : any 2 from D, E, A**
Level 2	3-4 (4-6)	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made. **D and, E OR A** **3 marks : at least 3 points. Any combination of D, plus E, or A** **4 marks : at least 4 points. Any combination of D, plus E, or A**
Level 3	5-6 (7-9)	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made. **D, E, AND A** **5 marks : at least 5 points. Must have combination of D, E, and A** **6 marks : at least 6 points. Must have combination of D, E, and A**

Question Number	Answer	additional guidance	Mark
7 (a)	An answer that includes • the role of an organism (1) • in its ecosystem / community/ habitat (1)	**ignore environment**	**(2)**

Question Number	Answer	Mark
7 (b)	**The only correct answer is D 1, 2, 3 and 4** ***A*** *is not correct because they are the same* family genus order phylum ***B*** *is not correct because they are same* family genus order phylum ***C*** *is not correct because they are the same* family genus order phylum	**(1)**

Question Number	Answer	Mark
7(c)	An explanation that makes reference to the following points: • a species is (defined as) a group of organisms that interbreed to produce fertile offspring (1) • some are same and some are different species by this definition / partially satisfied by these two closely related flies (1)	**(2)**

Question Number	Answer	Mark
7(d)	An explanation that makes reference to four of the following points: • (some flies settled on Hawaii Island some on Maui) so are geographically isolated (1) • so cannot interbreed / reproductively isolated (1) • no exchange of alleles / genes (1) • so evolve differently subject to different selection pressures (1) • different mutations accumulate and the two species are unable to breed together (1) • called allopatric speciation (1)	**(4)**

Question Number	Answer	Mark
7(e)	A description that makes reference to three of the following points: • look at similarities / differences in anatomical / behavioural / courtship song (1) • use bioinformatics to compare / molecular phylogeny (1) • the DNA sequencing / profiling / DNA barcoding / CBOL/ IBOL (1) • use gel electrophoresis to {compare DNA / amino acids/ proteins} (1)	**(3)**

(Total for Question 7 = 12 marks)

Number	Answer	Additional Guidance	Mark
9(a)	An explanation that includes four of the following: • dark moths were a result of (random) mutation (1) • (in industrial areas) {dark moths are less likely to be {seen / eaten} (by predators) / light moths are more likely to be {seen / eaten} (by predators) (1) • {dark moths have a selective advantage / light moths have a selective disadvantage} in industrial areas (1) • dark moths are more likely to (survive and) breed, passing on (new) allele (1) • allele frequency (for dark wing) increases (1)	Accept (random) mutation causes variation Accept ref to camouflage / blending in for less likely to be seen Ignore dark moths being eaten in rural areas Allele for dark wing is advantageous in industrial areas Accept allele frequency (for light wing) decreases	**(4)**

*9b

Level	Marks	
0	0	No awardable content
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

*9(b)	**L 1: up to three comments from any area** **L 2: up to 6 comments from at least two areas** **L 3: minimum of 6 comments, must be from 3 areas** **Indicative content** **Investigation 1: predation by birds** • data supports natural selection because very visible moths were eaten • better camouflaged moths not eaten **Investigation 2: recapture of light and dark moths** • data supports natural selection because in the industrial area, twice as many dark moths survived. • this matches the data from the bird predation investigation • in the rural area, almost three times as many light moths survived compared to dark moths **Investigation 3: map data** • data supports natural selection because non-industrial areas have mostly / all light-coloured moths • example of non-industrial area fitting this pattern eg northern Scotland, Cornwall • data supports natural selection because industrial areas have mainly / all dark-coloured moths • example of industrial area fitting this pattern eg named suitable city / region • data supports NS as prevailing winds blow air pollution to rural areas and affect numbers of moths + example • relevant comment on change between 1950s and 1970s **Confounding data:** • Investigation 2 – light form survival % are the same in industrial and rural areas, so does not support • if moths do not rest on tree trunks, camouflage against lichens is not relevant, so does not support • bats are main predators + camouflage does not matter as bats hunt at night, so likely to eat equal numbers of both forms • 1970s – changes in proportions of moths without changes in lichen cover, so does not support • suggests it may be the pollution itself causing the change, not the camouflage • No idea of sample size / SD • Comment on mark recapture technique • Assumes those not recaptured are eaten, but % recapture may not equal % survival • other factors may be involved eg not just due to pollution affecting natural selection	Level 3 (comments from 3 areas) 7 marks 6 comments 8 marks 7 comments, including 1 confounding 9 marks 8 comments, including 2 confounding

(Total for Question 9 = 13 marks)

Question	Answer	Additional Guidance	Mark

Question Number	Answer	Additional Guidance	Mark
7(a)	• 7×10^4	**ACCEPT** 7.0×10^4	(1)

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	• number of guanine and cytosine bases given as 317 203 092 **OR** number of thymine bases given as 204 202 736 **OR** number of adenine and thymine bases given as 408 405 472 • number of guanine bases calculated as 158 601 546	Correct answer with no working get 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	• one set of correct figures {selected / calculated} for Yap hadal snailfish (1) • 85.8 (%) (1) **OR** • one set of correct figures {selected / calculated} for Mariana hadal snailfish (1) • 85.6 (%) (1)	14 750 / 12 685 / 2 092 *85.816949152542372881355932203 39* 14 783 / 12 658 / 2 125 *85.625380504633700872623959954001* 1 mark if {incorrect rounding / too many dps given in answer} ECF correct % for correct numbers {used / added up} from diagram wrongly	(2)

Question Number	Answer	Additional Guidance	Mark
7(b)(iii)	A description that makes reference to three of the following: • All four fish {share the same (original) common ancestor / came from the same species} (1) • Yap hadal and Mariana snailfish are <u>most closely-related</u> / the zebrafish is the <u>least closely-related</u> (1) • Yap hadal and Mariana snailfish evolved from the same {species / common ancestor} (1) • The common ancestor of the {Yap hadal snailfish / Mariana snailfish} {evolved from / had} the same common ancestor as the Tanaka's snailfish (1) • Zebrafish are the <u>most distantly-related</u> because they diverged from the others {about 240 million years ago / the longest time ago} (1)	**NB IGNORE** years given unless contradictory **ACCEPT** had the most recent common ancestor Tanaka's snailfish is <u>closer-related</u> to the zebrafish than the other snailfish as they have the closest common ancestor **ACCEPT** evolved from the same species **ACCEPT** the three snailfish are <u>more closely related</u> as they share a (more) recent common ancestor	(3)

Question Number	Indicative content
*7(b)(iv)	**Indicative content:** **Aspect 1 : Isolation** • common ancestor lived in same area • example of allopatric speciation • because in different trenches • geographical barrier • which is shallower water **Aspect 2 : Selection pressures** • conditions in two areas were different • e.g. temperature, food, predators • therefore different selection pressures / description of **Aspect 3 : Natural selection story** • two species evolved from the common ancestor they shared • mutations occurred (in DNA) • some giving rise to advantageous alleles • new phenotypes enabling survival • example of phenotype described • survivors reproduced and passed down their alleles • increase in allele frequencies **Aspect 4 : Decrease in gene flow** • gene flow reduced between two populations • no longer interbreed together • over time became two separate species as they cannot interbreed to produce fertile offspring • as would have become reproductively isolated • because {did not recognise mating behaviour / incompatible genitalia} **Aspect 5 : Epigenetics** • epigenetic modification occurred • different genes became permanently switched off in the two species • these changes were inherited

Level 1

1 mark = any relevant comment

2 marks = demonstration of **some** understanding of **1** aspect

Level 2

3 marks = Good understanding of **1** aspect + **1** other aspect mentioned

4 marks = Good understanding of **2** aspects + **1** other mentioned

Level 3

5 marks = Good understanding of **2** aspects + **2** others mentioned

6 marks = Good understanding of **3** aspects + **1** other aspect mentioned which includes some specific detail relating to question scenario

Number	Answer	Mark
7(a)	**The only correct answer is C** ***A*** *is not correct because allopatric selection is an incorrect term* ***B*** *is not correct because directional selection would move the curve in one direction* ***D*** *is not correct because stabilising selection would result in one peak*	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	different {alleles} in a gene pool / species / population OR different {species} in an {area / habitat / environment / ecosystem / community}	**ACCEPT** genetic variation within a species	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	An explanation that makes reference to the following: • only small number / 10 introduced / {founder effect / genetic bottleneck} has occurred / (1) • (resulting in a) limited gene pool / few different alleles / inbreeding in zoos / no other lynx present to provide new alleles (1)	 **ACCEPT** converse for lynx in protected area **ACCEPT** converse for lynx in protected area **DO NOT ACCEPT** diversity of alleles	**(2)**

Question Number	Answer	Additional Guidance	Mark
7(c)	An explanation that makes reference to four of the following: any **two** from • {use of zoos / seed banks / captivity} to {prevent extinction / protect endangered species} (1) • {education about /raising money for / raise awareness}importance of conservation (1) • {breeding programmes / controlled feeding / removing predation / protect from poaching / veterinary care} to increase {numbers / population} (1) and any **two** from • need to avoid inbreeding by use of stud books / frozen sperm (1) • **ethical** issues (1) • loss of normal behaviours (1)	 **e.g** safari park **ACCEPT** any correct method **e.g**. cannot hunt / domesticated / reliant on humans	**(4)**

2 (a)	A description that makes reference to the following: • ethical reasons for maintaining biodiversity (1) • economic reasons for maintaining biodiversity (1)	example of ethical reason such as denying future generations the opportunity to use renewable resources/ genetic resources / aesthetic / maintain gene pool example of ecosystem services: provisioning services such as food clothing , fuel , medicines , building materials / regulating services / removal of toxins supporting services / soil formaton / nutrient recycling / cultural services tourism / allow maintain healthy ecosystem / prevent extinction (accept two ethical or two economic reason)	**(2)**

Question Number	Answer	Additional guidance	Mark
2(b)(i) **CLIP with 2b(ii)**	An answer that includes • calculation of numerator • calculation of denominator • correct calculation of D	Example of calculation 30 x 29 = 870 **870 scores 1 mark** (30 +42+20+56+12)= 160 870 ÷ 160 **÷ 160 scores one mark** D = 5.44 D = 5.4375 Correct answer with no working gains full marks	**(3)**

Question Number	Answer		Mark
2(b)(ii) **CLIP with 2b(i)**	An answer that makes reference to three of the following points: • same number of different species in region A and B (1) • more species evenness / similar relative species abundance in region B (1) • as numbers of each species almost equal (1) • (shown by) D value higher in region B / B more diverse (1)	allow species richness same allow converse for mp 2 3 4	**(3)**

(Total for Question 2 = 8 marks)

Question Number	Answer	Additional guidance	Mark
4(a)	An answer that includes • calculation of numerator • calculation of denominator • correct calculation of D D = 4.4 (3)	Example of calculation 20 x 19 = 380 (12 +56+0+6+12) = 86 380 ÷ 86 D = 4.42 or 4.4186 Correct answer with no working gains full marks allow 1 mark for 380 allow 1 mark for 86	**(3)**

Question Number	Answer	Additional guidance	Mark
4(b)	An answer that makes reference to three of the following points: • more (different) species in woodland A / higher species richness in A / no Woodrush and no Sedge in B (1) • more species evenness / similar relative species abundance in woodland A (1) • as numbers of each species more similar in woodland A (1) • no measure of diversity within a species (1)	**Accept** converse for woodland B B dominated by Holly genetic diversity	**(3)**

Question Number	Answer	Additional guidance	Mark
4(c)	An description that includes two of the following points: • use coordinates / random samples (1) • more samples / more quadrats / repeat sampling / larger area (1) • measure / count at same time of year / season (1) • sample more species (1)	not time of day sample more species	**(2)**

(Total for Question 4 = 8 marks)

Number	Answer	Additional Guidance	Mark
7(a)(i)	• correct calculation of energy in primary consumers (1) • correct calculation of percentage efficiency of energy transfer (1)	1.2×10^4 / 12000 (1200 / 14000) x 100 = 8.6 % Allow 8.57	2

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	An explanation that makes reference to three from: • (large amounts of) energy from producers is not transferred to primary consumers as producers have more {indigestible parts / inedible parts / parts not consumed}(1) • animals / primary consumers / secondary consumers have higher respiration rates than producers (1) • as more energy lost in {movement / heat loss} (1) • animals / primary consumers / secondary consumers lose more energy as {urea / excretion} (compared with producers) (1)	**Allow** more faeces released when consuming producers **Allow** different organisms have different amounts of indigestible / inedible parts **Allow** different organisms have different respiration rates **Allow** organisms have different levels of movement /heat loss	3

Question Number	Indicative content	
7 (b)*	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Descriptions** • crop yield is highest between 5 m and 10 m from hedgerow D • crop yield is lowest next to the hedgerow / crop yield is lower than the centre of the field up to 2.5 m • crop yield increases up to between 5 m and 10 m from the hedge and then decreases D • wind speed is lowest by the hedge D • wind speed increases with distance from the hedge D • temperature is higher by hedgerow / falls with distance D • hedgerows can increase crop yields, but fields need to be smaller D • hedgerows can take up land that could be used to grow crops D **Abiotic Explanations** • humidity is higher by the hedgerow A • reduced wind speed (by the hedge) increases the temperature A • transpiration /water loss / evaporation will be lower around hedgerow A • hedgerow acts as a wind break A • less than 2m from hedgerow productivity is lower due to competition / shading reducing photosynthesis A • between 5m and 15 m, higher temperature will increase photosynthesis rate A • higher temperature is closer to optimal enzyme temperatures A • wind can affect crops pollinated by wind A	6

	Biotic Explanations • pollinating species and predators increase productivity B • predators consume herbivores / pests B • pollinators are essential for seeded crops / example B • hedgerow may compete for nutrients / water / light B • less need for pesticides to be used when predator species live in hedgerows B		
Level	**Marks**		
Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made. **Descriptions of factors** **one mark: any two from D** **two marks: three from D**	
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made. **Descriptions and explanations** **three marks: any four points from D, A or B** **four marks: any five points from D, A or B and**	
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	

		Detailed explanation of all factors and how use of hedges can be beneficial **Descriptions and explanations** **five marks: any six points from D, A and B** **six marks: any seven points from D, A and B**	

Question	Answer	Additional Guidance	Mark

Question Number	Answer	Mark
7(a)(i)	The only correct answer is D (no yes yes) *A is incorrect as the genetic code is not overlapping* *B is incorrect as the genetic code is not overlapping* *C is incorrect as eukaryotes do have introns*	**1**

Question Number	Answer	Additional guidance	Mark
7(a)(ii)	An explanation that makes reference to two of the following: • because most amino acids have more than one triplet / code is degenerate (1) • (genes contain) introns / non-coding DNA (1) • changing amino acid sequences affects {secondary structure / tertiary structure / quaternary structure / bonding / protein structure} (1)	**Allow** codon for triplet **Allow** converse	**2**

Question Number	Answer	Additional guidance	Mark
7 (a)(iii)	A description that makes reference to the following: • **DNA** sequencing (1) • use gel electrophoresis (1) • comparing DNA band patterns / use bioinformatics to compare sequences in databases (1)	**Allow** Sangar sequencing **Allow** description of gel electrophoresis **Allow** fragments for bands **Allow** DNA hybridisation between two species	**2**

Question Number	Indicative content
7 *(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Descriptions (D)** • more diversity in wild for trees / non-woody species / non-endangered species / most species have higher diversity in wild / converse for seedbank • more diversity in seedbanks for endangered species / species of economic interest / converse for wild • non-woody species and non-endangered species have high variability / wide standard deviations • endangered species / trees how lower variability / lower standard deviations • the age in seed banks increases, the number of differences increases **Explanations (E)** • less breeding in seed banks / reproduction in wild increases variation • less gene flow in seed bank / more genetic drift occurs in wild • in wild more meiosis / crossing over / independent assortment / mutation / random breeding (to generate variation) • in the wild there is more selection pressure / natural selection • trees are slower growing / live longer, so less diversity • non-woody species have high reproduction rate so increased number of genetic changes • (for most) having fewer seeds stored means lower diversity • for endangered species there is inbreeding / genetic bottleneck / small gene pool (so lower diversity) • non-endangered species have high diversity due to higher numbers of each species / more breeding **Validity of data and conservation role (V)** • correct comment on whether differences are significant or not linked to overlapping error bars • (there is a correlation between genetic differences of seeds with age) but many outliers / less data for longer times • different group sizes so difficult to make (valid) comparisons / some groups have low numbers / low sample size (reduces validity) • shows need to keep rebreeding plants in seed banks to maintain diversity

	• show seedbanks play role in maintaining genetic diversity for conservation of endangered species (as more diversity in the seedbank) • no idea which dot is which species in scatter graph

Level	Marks	
0	0	**No awardable content**
1	1-2 (1-3)	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. **One mark: any one comment from D, E, or V** **Two marks: any two comments from D, E, or V**
2	3-4 (4-6)	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure. **Three marks: any three from two of D, E, or V** **Four marks: any four from two of D, E, or V**
3	5-6 (7-9)	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. **Five marks: any five from D, E <u>and</u> V** **Six marks: any six from D, E, <u>and</u> V and must relate to both graphs**

Answer	Additional Guidance	Mark
er calculated with units	Example of calculation: 90 – 16 = 74 74 ÷ 2 = 37 % year^{-1} or 74 ÷ 24 = 3.08 % month^{-1} / 3.1 % month^{-1} / 3 % month^{-1}	(2)

Answer	Additional Guidance	Mark
es reference to the following: rmination} requires similar conditions as the on is affected by l / light intensity / wavelength / humidity / ıs not used seeds would not germinate even if	**Accept** other relevant abiotic factor	(3)

Answer	Additional Guidance	Mar
es reference to four of the following: ermination} high in metal containers (1) ave similar properties to metal containers (1) glass} containers keep {air / moisture} out ter content is kept below 8% (1) lass without removing lid (1)	**Accept** converse for paper / cellophane	(4)

Answer	Additional Guidance	Mar
bility / results / data)	**Accept** allows identification of anomalous result **Do not accept** if in list	(1)

Answer	Additional Guidance	Mark
es reference to the following: affected by eriod / light and dark period} (1) olves {phytochrome / P_R / P_{FR}} (1)	**Accept** florigen	**(2)**

Indicative content
date's deployment of knowledge and understanding of the material in relation neric mark scheme. tive and candidates are not required to include all the material which is cluded in the response must be scientific and relevant.
ls / public awareness / research ndangered species / safe environment / protect from poachers, habitat loss, protected from disease
nen / exchange animals
inement, change behaviour / habitat differs
successfully release animals back into the wild vill further endanger the wild population ld or visit a sanctuary / in a reserve

	Additional Guidance	M
	ACCEPT no new species listed means no change in total	(

Additional Guidance	Mark
Example of calculation 1685 - 400 = 1285 1285 ÷ 30 = 42.83 / 43 Correct answer with no working gains full marks **ACCEPT** one mark for ÷ 30 in working	**(2)**

Descriptor
basic information with some attempt made to link knowledge and understanding ***ne reason against = 1*** ***explains one reasons against OR*** ***s against = 2***
with occasional evidence of analysis, interpretation and/or evaluation of the linkages and lines of scientific reasoning with some structure. ***l one against = 3 Explains one reason for and two against = 3*** ***l two against = 4***
is supported throughout by evidence from the analysis, interpretation and/or formation. l-developed and sustained line of scientific reasoning which is clear, coherent and ***l three against or Explains three reasons for and two against = 5*** ***/ conclusion = 6***

Question Number	Answer	Additional guidance	Mark
5(b)(i)	• Calculation of N(N-1) (1) • Calculation of $\sum n(n-1)$ (1) • Calculation of Index of biodiversity (1)	Example of calculation: 130 x 129 3580 4.68 130 x 129 **OR** 16770 **OR** 130 (130-1) **(one mark)** 3580 **(one mark)** 4.68 **(3 marks)** **Correct answer gains all three marks**	**(3)**

Question Number	Answer	Additional guidance	Mark
5(b)(ii)	An answer that makes reference to the following: • takes population numbers into account / takes account of abundance (1)	**Accept** species evenness **Accept** populations may change / the number of individuals of each species may change	**(1)**

Question Number	Answer	Additional guidance	Mark
5(b)(iii)	An explanation that makes reference to two of the following: • there are many food chains / food webs are complex (1) • because there are alternative food sources (1) • there are different predators (1) • range of niches / many habitats (1) • there is {high genetic diversity / many alleles / large gene pool} **and** some {survive / have advantageous alleles} (1)	**Ignore** lots of food **Accept** many food sources / different prey / **Accept** different niches **Accept** many alleles **and** some (advantageous) alleles) are passed on	**(2)**

(Total for Question 5= 12 marks)

Indicative content		
cording to candidate's deployment of knowledge and understanding of the qualities and skills outlined in the generic mark scheme. w is not prescriptive and candidates are not required to include all the material ant. Additional content included in the response must be scientific and on: sity is important for medicines / wood products / sustainable products / prevent vation d / homes / food for indigenous people and recreational opportunities for non- s to greenhouse effect / global warming / climate change / raised carbon soil erosion / landslides / flooding / desertification mic implications for employment / national income r wood products used in building of houses / fuel r cattle farming / crop growth habitat destruction / reduction of biodiversity / extinction	owing: conserved (1) ood / shelter} (1) still exist (1) ees} (1)	**(4)**

	Additional guidance	Mark
ving: f all species (1) ecies} (1)	Eg. quadrat / sweep net / tree beating / light trap Ignore species richness / evenness / abundance	**(3)**

ıowledge and understanding to the given context with generalised made with limited linkage to a range of scientific ideas, processes, th some attempt made to link knowledge and understanding to the ***ıainst deforestation = 2*** ***wo reasons against deforestation = 2***
:anding by selecting and applying some relevant biological ıally supported through linkage to a range of scientific ideas, ıf scientific reasoning with some structure. ***= 3 Explains one reason for and two against = 3*** ***= 4***
nderstanding by selecting and applying relevant knowledge of ed throughout by sustained linkage to a range of scientific ideas, tained line of scientific reasoning which is clear and logically ***or three against with some evidence of detail = 5*** ***of which reflects evidence presented = 6***

Number	Answer	Additional Guidance	Mark
8(a)	An explanation that makes reference to the following: • number of different {species} within a habitat / richness / relative number of each one {species} / {species} evenness (1) • genetic variation (within a species) / heterozygosity / degree of inbreeding (1)	not just numbers of organisms	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	• calculation of N (N-1) (1) • calculate ∑ n (n-1) (1) • calculation of D (1)	N = 126 N (N-1) = 15750 6320+506+182+72=7080	**(3)**
		15750 ÷ 7080 = 2.2 allow 2.23 or 2.225 or 2.2246 allow 1 mark for 6320+506+182+72 and allow 1 mark for 1570	

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An explanation that makes reference to the following: • smaller number of different species within this pond / low species richness so that N is lower (1) • few of some species whilst others are very {abundant / low species evenness} so that n is higher (1)	must refer to some species high numbers **and** other species low numbers	**(2)**

Question Number	Indicative content
*8c	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. <u>benefits of in-situ</u> It doesn't involve removing species from their natural ecosystems. It doesn't lead to behavioral change stereotypy It is not as disruptive as ex situ conservation, i.e. ecological integrity is maintained. It involves protection of larger populations and conservation of organisms and their habitat as a whole. The organisms/species get the opportunity to evolve. Allows and facilitates scientific studies of the area. Encourages Ecotourism <u>risks of in-situ</u> It requires larger areas Animals are always under threat of several diseases or any natural disasters. Risk of increased inbreeding and thus reduced fitness which is known as homozygosity. The animal species could be less productive and thus expensive to be monitored and maintained.
	Poachers and ecological tourists may find these thriving habitats as an opportunity and may cause harm. <u>benefits of ex situ</u> It involves protection of species from external threats like predation and poaching. Selective breeding processes are put in place. Can keep breeding logs / studbooks etc It involves reintroduction of several organisms that have left their natural habitat Improvised quality of off-springs can be obtained Many seeds can be stored in seed banks take up little room <u>risks of ex-situ</u> It can be considered only for a few kinds of species. Due to human interference, rare species remain under threat. Inbreeding small population size Hybridization Captive species show divergent genetics/ subject to different selective pressure allele frequencies change. Poor germination rate. Costly method of conservation.
	Harm to seeds by pests

Level	Mark	Descriptor
	0	No awardable content
1	1-2	The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. explains what in-situ and ex-situ are ***Explains one benefit or risk for one method =1*** ***Explains two benefits or risks for one method or one benefit or risk for each method = 2***
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. ***Explains two benefits and one risk s for each method = 3*** ***Explains two benefits and two risks for each method = 4***
3	5-6	An explanation is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured. ***Explains two benefits and two risks for each method with some evidence of detail = 5***

Number	Answer	Additional Guidance	Mark
5(a)	An answer that makes reference to the following: • correct structure of glycerol (1) • correct structure of three fatty acids (1)	Max one mark if other molecules e.g. water added to right hand side **Accept** 3 x one fatty acid	2

Question Number	Answer	Additional Guidance	Mark
5 (b)(i)	C 3 *A is incorrect because palmitic, myristic and stearic acid are saturated fats* *B is incorrect because palmitic, myristic and stearic acid are saturated fats*		1
	D is incorrect because palmitic, myristic and stearic acid are saturated fats		

Question Number	Answer	Additional Guidance	Mark
5 (b)(ii)	An answer that makes reference to four from the following: • %SFC for both decreases as temperature increases for both cocoa butter and palm oil / both have 5% SFC at 35 °C (1) • the % SFC of cocoa butter is higher at all temperatures (except 35 °C) (1) • because cocoa butter has higher percentage of / more saturated fat (1) • so fatty acid chains can associate with each other more easily (1) • the % SFC of cocoa butter decreases more steeply above 25 °C / larger decrease after 25°C (1)	**Accept** converse **Accept** converse **Accept** pack more tightly together / has straight chains/rods which pack tightly together higher density of intermolecular contacts/bonds	4

Question Number	Answer	Additional Guidance	Mark
5 (c) (i)	An explanation that makes reference to two from the following: • a genetic bottleneck has occurred (1) • resulting in a smaller gene pool (1) • so the probability of receiving two recessive alleles is higher (1)	**Accept** lower genetic diversity **Accept** inbreeding / higher chance of two organisms have similar alleles	2

Question Number	Answer	Additional Guidance	Mark
5 (c)(ii)	An explanation that makes reference to three from the following: • therefore animals from different populations can move across territories / forest to forest (1) • therefore increasing genetic diversity / widens gene pool / increased allele number (1) • and balances the needs of local people with conservation / retains jobs for local people (1) • local people are more likely to maintain the bridges (1)	**Accept** animals from different forests can move in / more outbreeding	3

Question Number	Answer	Additional Guidance	Mark
5(c)(iii)	An answer that makes reference to one from the following: • {banning export / import trade of species} preventing {poaching / illegal trapping} (1)	**Accept** {countries} sign treaty / agree preventing {poaching / trapping / exports / imports / trade}	**1**

Question	Answer	Additional Guidance	Mark

Number	Answer	Additional Guidance	Mark
10(a)	An answer that includes the following • the rate at which producers make organic material (by photosynthesis) / the rate at which light energy is incorporated into organic matter (by plants / producers) / rate at which carbon is fixed into organic matter (by photosynthesis) (1) • suitable units of biomass per area per time or energy per area per time (1)	Accept organic matter / carbon compounds / biomass Accept plants / autotrophs Do not accept: energy produced Accept energy converted / turned into Accept eg g m^{-2} $year^{-1}$, kg m^{-2} $year^{-1}$, kJ m^{-2} $year^{-1}$ g (of carbon) m^{-2} $year^{-1}$ Accept cm^{-2} or min^{-1} as units Accept m^{-3}	**(2)**

Question Number	Answer	Additional Guidance	Mark
10(b)	A description that includes two of the following: • (energy passes) to other appropriate animals (1) • (energy remains) in plant biomass (1) • (energy) released in respiration (in plants) (1)	Accept eaten by herbivores / primary consumers / insects / rabbits etc Accept plants grow / energy stored in plants (remain in the field and) broken down by decomposers remains in humus in the soil Accept lost as heat from respiration used for active transport / other correct metabolic processes	**(2)**

Level	Marks	
0	0	No awardable content

1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Question Number	Answer	Mark
10(c)	Level 1: links information given to effect on dung beetles (up to 3 points from anywhere) Level 2: links information given to effect on dung beetles (up to 6 points from a minimum of two categories) Level 3: links information given to effect on dung beetles (up to 9 points with at least two from each of three categories) **Indicative content** **Threats to dung beetles (T points)** • (less grazing animals on land) so less dung available ie reduced food source • (farmland used for building / development) so reduced habitat • (animals kept in sheds overwinter) so food source unreliable / not constant • (routine use of anti-parasitic drugs) so drugs in animal faeces which kill dung beetles • (isolated populations of dung beetles) so genetic diversity is reduced • (isolated populations of dung beetles) - small populations of dung beetle species have a small gene pool, so allele frequencies can change rapidly • small populations are more vulnerable to disease • (many) dung beetles feed specifically on the dung of particular species, so reduction in species of grazing animals decreases diversity **Benefits of dung beetles (B points)** • (remove dung from fields) so more access for grazing by animals / plants get light for photosynthesis • (remove dung from fields) so less chance of parasites living in dung and reinfecting cattle • (bury dung underground) so decomposers can break it down • decomposition of dung is faster if dung beetles are present • (decomposed dung) increases mineral content of soil • (eaten by birds etc) so provide food for other animals / loss of dung beetles could lead to collapse of food chains	

	Wider points and consequences for farming (W points) • no evidence or stats to prove or disprove statement • if farming practices change animals will suffer eg may die if left outside over winter • if farming practices change, less economically viable to farm / yields may be lower • if farming practices change, less food produced for human consumption • climate change may have an effect on decline of dung beetles eg rise in temperatures, changed rainfall patterns • a new predator might be responsible for decline • urbanisation might be causing change, not farming practices • (routine use of anti-parasitic drugs) kill other beneficial invertebrates (as well as dung beetles) • pesticides (anti-parasitic drugs) may affect other animals in food chain: accumulation • adding fertilisers disrupts dung beetle life cycle • ploughing pasture disrupts dung beetle life cycle • (digging tunnels) improves soil structure by aeration • dung beetles may be involved in seed dispersal (seeds in faeces being moved around by beetles) • cattle contribute to global warming, so better not to farm cattle

Total for Question 10 = 13 marks

Number	Answer	Additional Guidance	Mark
10(a)	An answer including at least one benefit and at least one difficulty **Benefits** • prevents habitat loss (1) • marine communities may contain species which are dependent on each other (all are protected) (1) • avoids problems of reintroducing species to the habitat (as in ex-situ conservation) (1) • increased education / public awareness (1) **Difficulties** • cannot control movement of animals in and out of protected areas / some marine animals migrate (1) • laws may restrict commercial or leisure activities currently taking place (1) • difficult to {monitor / police} (illegal activity underwater / at sea) (1) • difficult to monitor species (over large area) (1)	Allow prevents named damage to habitat / fishing Allow ref to food chains / webs protected Allow (stay in own habitat) so does not affect behaviour / less trauma /less vulnerable to disease Accept animals are still vulnerable outside the boundaries of protected area Accept named activities eg fishing, sailing, Allow people might not follow regulations Allow still affected by climate change / pollution from outside zone	**(4)**

Level	Marks	
0	0	No awardable content
1	1-3	Limited scientific judgement made with a focus on mainly just one method, with a few strengths / weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding, but with limited evidence to support the judgement being made.
2	4-6	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.
3	7-9	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.

	Answer
10(b)	**Level 1**: links information given to effect of seagrass **or** pilot study as below (up to 3 points from anywhere) **Level 2**: links information given to effect of seagrass **and** pilot study 4 marks – any combination of 4 points from E **and** B / P 5 marks – any combination of 5 points from E **and** B / P 6 marks – any combination of 6 points from E **and** B / P **Level 3**: links information given to effect of seagrass **and** benefits **and** problems of pilot study 7 marks – 7 points max 5 from E, plus at least one B **and** one P 8 marks – 8 points max 5 from E plus a total of three from B **and** P 9 marks – 9 points max 5 from E plus at least 2 from B **and** 2 from P **No credit for points lifted from information given without qualification eg *seagrass stores a lot of carbon.***

Indicative content

Effects of seagrass meadows - general (E points) Allow converse for loss of seagrass

- *Seagrass stores a lot of carbon*, which will slow or stop climate change / ref greenhouse effect / global warming / named effect
- Seagrass removes CO_2 from seawater reduces ocean acidity
- *Seagrass protects coastal areas from erosion*, preventing flooding
- *Seagrass protects coastal areas from erosion*, prevents damage to coastal habitats or property / link to reduced biodiversity
- *Seagrass acts as a nursery for young fish*, increasing fish stocks – any relevant benefit eg to humans
- *Seagrass acts as a nursery for young fish* – any relevant benefit eg to food chains / niche
- *Seagrass meadow habitat supports a range of species* increasing / maintaining biodiversity
- Seagrass produces oxygen (in seawater) when photosynthesising, benefits other species

Benefits of Wales pilot study (B points) - this is not benefits of seagrass, which are E points above

- small scale study to assess effects
- uses seeds from UK sites, so likely to be compatible with other species in the community
- different planting methods trialled to find the best method
- is restoring a seagrass meadow habitat (not making one in a new place), so does not damage other habitats
- increases local biodiversity by providing food / shelter for animals
- the newly planted area should be protected by law / made an MPA / MCZ
- contributes to knowledge about restoring seagrass meadows / research
- benefit of method eg *bags are biodegradable* so won't pollute ocean (up to 3 points)
- action needed because seagrass is threatened / declining / endangered

Problems with Wales pilot study – could be described as improvements (P points)

- very small area being planted (only *2 hectares*) so may not be representative / will not make a big difference
- removal of seeds from other UK sites may damage viability of these sites
- uses seeds from other UK sites, so may not be compatible with other species in the community
- very low success rate (only *4% successful germination*), allow comment on time **and** success rate eg long time to have effect / only 8 months data
- very labour intensive – *seeds collected by hand by divers* – so hard to replicate on a large scale / time-consuming.
- problems that caused decline of seagrass meadows still exist eg pollution from agricultural run-off / dredging – humans need to change
- problem with method eg ropes / pegs might damage marine life (up to 3)
- should protect the existing seagrass meadows

Total for Question 10 = 13 marks

		Additional Guidance	Mark
:			
s then	(1)		
} /	(1)		
pecies			
ites} /	(1)		
s			(3)

		Additional Guidance	Mark
:			
is	(1)	ACCEPT converse statement	
t /	(1)		
			(2)

Additional Guidance	Mark
e.g. temperature / wind speed / humidity / rain / previous weather/ sunlight	
e.g. number of sweeps / size of nets / may not catch all species / some not caught / sampling was not random / subjective / relies on judgement when all are collected / bias / should grid areas / some not seen / some may fly away	
e.g. some butterflies not present at different times / hatch at different times / migrate at different times / should look at other months	
e.g. lots of fields needed / may be other differences between fields / sizes of fields / may differ / needs more repeats over more years	
IGNORE ethical issues	(4)

		Additional Guidance
		Example of Calculation
78)	(1)	N(N-1)Σn(n-1)
	(1)	= 5.96
		Correct answer with no working gains full marks

		Additional Guidance
e following:		ACCEPT converse statements
ess / more varieties	(1)	
	(1)	
g areas /	(1)	
nsecticide / fertiliser	(1)	

wer	Additional Guidance	Mark
al (1)	Example of calculation: 400 x 207 = 82800 cm^3 **Accept** calculation of total haemoglobin per cm^3 kg^{-1} blood: 207 × 216 = 44712 **Accept** calculation of concentration of haemoglobin in one seal: 216 × 400 = 86400	
$^{-3}$ (1)	216 ÷ 1000 = 0.216 g cm^{-3}	
concentration of haemoglobin (1)	0.216 x 82800 = 17885 g Correct answer with no working gains full marks **Accept** for two marks a correct answer with no units / wrong units **Accept** for three marks: 17884.8 g / 17880 g / 17890 g / 17900/ 18000 g / 17.8848 kg / 17.885 kg / 17.89 kg / 17.9 kg / 18 kg	**(3)**

nal Guidance	Mark
	(1)

	Additional Guidance	M
the g / sale / trade / (1) red species (1)		

	Additional Guidance	M
of the e pool / ns) (1) rmful	**Accept** small / restricted gene pool	

	Indicative content
biological knowledge and understanding to the given context with	ing to candidates' deployment of knowledge and understanding of the material i ls outlined in the generic mark scheme.
ormation with some attempt made to link knowledge and	not prescriptive and candidates are not required to include all the material whic nal content included in the response must be scientific and relevant.
terns from at least one of A or B	
and understanding by selecting and applying some relevant	en maximum depth and maximum time holding breath etween mass of animal and depth maximum time holding breath and mass of mammal uires larger oxygen storage as can't breathe underwater s oxygen to release energy
s and lines of scientific reasoning with some structure.	
with explanation from at least one of A or B	
ledge and understanding by selecting and applying relevant ots.	en volume of oxygen in body and maximum depth en concentration of haemoglobin in blood and maximum depth ygen stored in muscle and maximum depth sess myoglobin acting as an oxygen store in muscle bour seal have more oxygen stored in lungs / Weddell seal and Northern ygen stored in lungs ults in more buoyancy so deeper diving mammals have less stored in lungs ood volume and haemoglobin concentration results in very high blood oxygen
ped and sustained line of scientific reasoning which is clear and	od so higher haemoglobin concentration and blood volume in animals that dive
d explanation of patterns from both A and B with	s of oxygen stored in muscle
	upport explanation . to support explanation, for example, determining total haemoglobin als.

Number	Answer	Additional Guidance	Mark
4(a)(i)	An explanation that makes reference to three of the following: • (biodiversity is low) because there are few species (1) • because there is a lot of trampling (1) • because animals are disturbed (by noise) (1) • because grass is mown (makes it difficult for other species to establish themselves) (1)		(3)

Question Number	Answer	Additional Guidance	Mark
4 (a)(ii)	An answer that makes reference to the following: • calculation of N(N-1) (1) • calculation of sum of n(n-1) (1) • calculation of D (1)	Example calculation 8556 1058 8.1 / 8.09 / 8.087 Correct answer with no working gains full marks	(3)

Question Number	Answer	Additional Guidance	Mark
4 (a)(iii)	An answer that makes reference to six of the following: • quadrats not placed at random (1) • {size / number} of quadrats not mentioned (1) • plants sampled at various intervals, animals at regular intervals (1) • {animals observed / no mention of how animals are counted} (1) • animals may {hide / move away / be counted twice} (1) • {only path sampled / inner area of woodland not sampled} (1) • not all animals identified to species level (1) • survey done at only one {time of year / time of day} (1)	Allow size of sample area not mentioned Allow description of pitfall traps, sweep nets, mark release recapture etc. could be used	(6)

Question Number	Answer	Additional Guidance	Mark
4 (b)	An explanation that makes reference to the following: • biodiversity decreases (1) • one relevant reason given (1)	Allow • because honeybees will compete with natural pollinators (for pollen / nectar / food) (1) • because populations of wild pollinators decrease (1) • because many wild pollinators will also provide food for other species (so they decline due to lack of food) (1)	(2)

Number	Answer	Additional Guidance	Mark
9(a)	An explanation that makes reference to two of the following: • fungi colonise new areas (1) • fungi cause decomposition (1) • so mineral ions are recycled within the ecosystem (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	An explanation that makes reference to three of the following:		
	• the numbers are very small causing a genetic bottle neck (1)	Allow reference to founder effect	
	• so that variation in the gene pool may have been reduced (1)	Allow small gene pool	
	• causing increased likelihood of inbreeding effects (1)	Allow inbreeding depression, Allow early offspring may have come from only one male	
	• such as accumulation of disadvantageous mutations (1)	Allow greater chance of receiving two recessive alleles	**(3)**

9(b)(ii)

Level	Marks	
0	0	No awardable content
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

9bii **Applying marking points** These are indicative marking points and other relevant information should be credited **Level 1** 1 mark: any point 2 marks: any two points 3 marks: any 3 points	**Justification for using poison to kill feral cats** 1. less potoroos killed (+) 2. potoroos less likely to become extinct (+) 3. feral cats are an introduced species (+) 4. there are very large numbers of feral cats (+) 5. increased fungal spread in ecosystem (by potoroos) (+) 6. introduced species will be killed but native species unharmed (+) 7. biodiversity remains higher if native species not killed (+) 8. sausages are designed to target cats (+) 9. native species less likely to become extinct (+) 10. poison is biodegradable (+)
Level 2 4 marks: 4 points, must have + and - 5 marks: 5 points, must have + and - 6 marks: 6 points, must have + and - **Level 3** Points must come from all three sections 7 marks: 7 points, must have + and - 8 marks: 8 points, must have + and – 9 marks: 9 points, must have + and -	**Reasons not to kill feral cats with poison** 1. pets may be killed (-) 2. other animals may be killed (-) 3. lots of people object to this (petition) (-) 4. sausages could be attractive to wild species as well (-) 5. government could use other methods to reduce population of feral cats (-) 6. suggested other methods eg spaying, shooting (-) 7. killing cats does not deal with threat from foxes (-) 8. plants / kangaroos are killed to make the poison (-) 9. feral cats are behaving naturally and should not be punished for this (-)
	Wider points 1. poison made from native plants so less likely to kill native animals (+) 2. biodegradable poison so action now will not affect animals in the future (+) 3. potoroos require special protection as there are such small numbers / endangered (+) 4. idea of balance needed in ecosystem (+) 5. cats have no natural predators in Australia, so it is justified to kill them (+) 6. ethics of government choosing which species to kill (-) 7. government could continue the breeding programme for potoroos (-) 8. effect on food chain of killing 2m feral cats (positive or negative) 9. feral cats may develop resistance to the poison (-) 10. government could try a small-scale trial to find effects of cull (-)

Question Number	Answer	Additional guidance	Mark
9(a)(i)	An explanation that makes reference to two of the following: • a founder effect has occurred (1) • so only a small range of alleles / small gene pool / low genetic diversity / low genetic variation (1) • high chance that two (harmful) recessive alleles will be inherited / high chance both parents carry (harmful) recessive allele (1)	**Accept** bottleneck **Do not accept** small number of genes **Accept** high chance both parents are heterozygous (and have harmful alleles)	**(2)**

Question Number	Answer	Additional guidance	Mark
9(a)(ii)	• p calculated (1) • 2pq calculated (1)	0.7 0.42 or 42 % **(two marks)** **One mark** for 0.7 in the working **Correct answer gains both marks**	**(2)**

Question Number	Answer	Additional guidance	Mark
9(a)(iii)	An answer that makes reference to two of the following: • no migration (1) • no sexual selection / natural selection (1) • no genetic drift / large population (1) • no mutation (1) • random mating / mixing (1)	**Accept** none leave population / none enter population **Accept** isolated population **Accept** no selection pressure	**(2)**

Question Number	Answer	Additional guidance	Mark
9(a)(iv)	A description that makes reference to two of the following: • ban on movement of lions (between countries) / ban on trade / control of trade (1) • by countries that {sign / agree} the treaties (1) • ban on {poaching / killing / hunting} of animals (1)		**(2)**

Question Number	Indicative content
***9(b)**	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Descriptions of graphs (G)** • all types of animals have more endangered species than threatened (G1) • more mammals / birds kept than invertebrates / amphibia (G1) • not that much difference between number of threatened an endangered amphibia / big difference between threatened and endangered for mammals / birds (G1) • zoos carry out research on many {mammals / birds} / little research on invertebrates (G2) • zoos support large amounts of in situ conservation for all species (G2) • high proportion of invertebrates have in situ conservation (G2) • ex situ conservation is low for {mammals / birds} / relatively high for amphibia (G2) **Knowledge (K)** • ex-situ conservation is keeping animals in zoos / in situ is keeping animals in habitats • zoos help prevent extinction of species / protect from poachers / predation ***ex-situ*** • leads to inbreeding / behaviour changes / ethical issues / unnatural environment • develops breeding programmes for release / allows scientific research / educational work • breeding programmes / stud books etc reduce genetic problems • modern zoos have enriched environments / more natural environments ***in-situ*** • expensive / may conflict with local people • also helps other species / habitats **Discussion points (D)** • some of the species in the zoos are just kept as exhibits rather than for conservation • the zoos raise money / awareness / research for in situ conservation / protect animals in habitats

	• fewer invertebrates in the zoos are kept for 'exhibits' (as less popular with visitors) / most are kept for conservation • more conservation of invertebrates / amphibia could be carried out • clear statement that some of the ethical issues of zoos are outweighed by benefits for some species • more research / raising of awareness could done on amphibia / invertebrates • difficult to make conclusion as no information about exact species / invertebrate grouping is very large • no information about the number / type of zoos assessed • only looks at numbers of threatened and endangered species / needs other categories / needs to include other groups e.g. fish / reptiles

	Marks	AO2 discuss
0	0	No awardable content
1	1-2 (1-3)	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. **1 mark: any two comments from any of G, K, D** **2 marks: any three comments from any of G, K, D**
2	3-4 (4-6)	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure. **3 marks: any four comments from at least two of G, K, or D** **4 marks: any five comments from at least two of G, K, or D**
3	5-6 (7-9)	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. **5 marks: any five comments and must be from G, K, and D** **6 marks: any six comments and must be from G, K, and D** **must have considered both graphs**

(Total for Question 9= 14 marks)

	Additional Guidance	Marl
)	**ACCEPT** less nutrient recycling **ACCEPT** not fertilised by faeces	2

	Additional Guidance	Mark
following: } (on Guam) (1) 1985 / Island collared ed ground dove)	**ACCEPT** other correct dates **ACCEPT** Species go extinct at different times	
s to increase / es / food for others (1) others (1)	**ACCEPT** reduced competition between birds (allows some bird species to increase) / reduced interspecies competition (allows some bird species to increase)	4

	Additional Guidance
n-1)	Example of calculation = 3906 (1) = 2604 (1) 3906 ÷ 2604 = 1.5 Correct answer with no working gains full marks

Answer	Additional Guidance
:o the following: / numbers of organisms (1) s in {each species vary} (1)	**ACCEPT** converse for both Mps **ACCEPT** population sizes can vary for two marks

	Additional Guidance	Mark
	ACCEPT cryogenics	
ɔs / sterilise (1)		**4**

	Mark
; glycosidic bonds	
s s	**1**

9 (a)	N		**(1)**

Question Number		Additional Guidance	Mark
9 (b)	An explanation that makes reference to four of the following: • (because) there are more species of woody plants in the older hedges (1) • If hedges were destroyed {there would be a large loss of biodiversity / many species would be lost} (1) • older hedges provide more niches (1) • (so that) more species of {invertebrates / vertebrates / animals / plants} (are associated with older hedge) (1) • (Therefore) hedges provide {shelter / food / nesting sites} / allow safe movement of animals (for {interbreeding / genetic variation}) (1)	Accept there is a positive correlation Accept if hedges were destroyed it would take a long time {for biodiversity to recover / for species number to recover} / if hedges are destroyed there are less niches Accept some plants are found only in older hedges Accept biodiversity increases as age of hedge increases	**(4)**

Question Number	Answer	Additional Guidance	Mark
9 (c)	• avoid {bias / underestimate / overestimate} (1)	Accept to get a representative sample	**(1)**

Question Number	Answer	Additional Guidance	Mark
9 (d)(i)	An answer that makes reference to one of the following: • stems are {stronger / less likely to break / better supported} • more {mineral ion / water} transport (1)		**(1)**

Question Number	Answer	Additional Guidance	Mark
9 (d)(ii)	A description that makes reference to three of the following: • cut thin sections (of the stem) (1) • from same height of stem in young and old plants (1) • {use a stain / named stain} to see xylem (1) • measure thickness of xylem tissue (1)	Accept cut a core (if rings are being measured) Measure thickness of {rings / xylem} 1 mark if potometer used in method	**(3)**

Question Number	Answer	Additional guidance	Mark
9 (e)	An answer that makes reference to five of the following: • cut potato into chips of same size as this {gives equal surface area (to volume ratio) / affects osmosis} (1) • place potato chips in range of {salt / sucrose} solutions to allow {osmosis / water to enter / water to leave} (1) • blot chips to remove surface water (1) • measure (percentage) change in {mass / length} and {determine loss or gain of water / plot graph} (1) • identify where line crosses x axis as this represents {no change in mass / length / the estimate of water potential} (1) • compare these lines for different ages of potato tissue (1) • use same temperature as this affects {osmosis / diffusion} / leave potato for same time in solutions as this affects {osmosis / diffusion} / use same {potato / variety of potato} as this affects {water potential / osmosis / diffusion} (1)	Accept use a cork borer to give samples of standard size (linked to SA or osmosis) Accept dry using a paper towel Accept measure initial {length / mass} and final {length / mass} to find change	**(5)**

Number	Answer	Additional Guidance	Mark
9(a)(i)	The only correct answer is **B** β glucose *A is incorrect because cellulose does not contain a glucose* *C is incorrect because cellulose does not contain ribose* *D is incorrect because cellulose does not contain ribose*		**(1)**

Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	A drawing showing the following: • Correct structure drawn (1) *Hexagonal ring with oxygen in correct place in ring.* *CH_2OH in correct place.* *All OHs apart from Carbon 1 in right places.* *Allow Hydrogens to be just stalks.* • OH groups shown correctly on carbon 1 (1) *pointing in same direction as CH_2OH*	**Do not accept** if water molecule also released / drawn	**(2)**

Question Number	Answer	Additional Guidance	Mark

9(a)(iii)	An explanation that makes reference to three from the following points: • (cellulose molecules are) straight / not helical (1) • (many) hydrogen bonds hold molecules / chains / layers together (1) • (strong) to prevent cell lysis / cells bursting / maintain turgidity / resist (turgor) pressure (1) • (polar nature of glucose) allows water /minerals to diffuse through (1)	**Accept** not coiled **Accept** hydrogen bonds between microfibrils **Accept** other correct functions of strong cell wall	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	• (index of diversity) takes into account populations (of each species) (1)	**Accept** considers abundance / number of each species **Accept** because an area could have many different species but different populations	**(1)**

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An answer that makes reference to two from the following points: • other species are also conserved (in the ecosystem) (1) • animals are not humanised / behaviours are natural / no change to behaviour (1) • less inbreeding occurs (1)	**Accept** converse for *in situ* **Accept** other species are protected / food webs are maintained / maintains biodiversity / maintains links in ecosystem **Accept** more space for animals **Accept** no need to transport animals **Accept** less inbreeding depression / maintain gene pool	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(b)(iii)	An explanation that makes reference the following points: • biodiversity has increased (in the paper project area) **more** (than the protected area) (1) • as less / no grassland is burnt / less poaching (1) • (more) niches are available / habitats are not destroyed / elephants transfer plant seeds (1) • local people make money from the paper project / if the elephants are not present, local people lose a source of income (1)	**Accept** biodiversity has increased but {did not increase / went down} in area where people are banned **Accept** grassland burning / poaching still occurs in unprotected area **Accept** converse for protected area **Accept** converse for protected area **Accept** people have a vested interest in the elephants / make a profit	**(4)**

Question Number	Answer	Additional Guidance	Mark
9(c)	A description that makes reference to two of the following points: • not all countries sign the treaty / signing the treaty is voluntary (1) • many species move across national boundaries (1) • monitoring is expensive / some countries are too large to monitor / high financial rewards for {poaching / smuggling} / CITES (only) prevents trade (1)	**Accept** the treaty is not legally binding (within nations) **Accept** some species migrate / have very large ranges **Accept** not all species are classed as endangered **Accept** countries may not be able to monitor within their borders **Accept** some poaching will continue	**(2)**