OCR A-LEVEL BIOLOGY A · H420

BIOLOGY



EXAM QUESTION PACK

4.2.2 CLASSIFICATION AND EVOLUTION

SCORE	PERCENTAGE
/194	%

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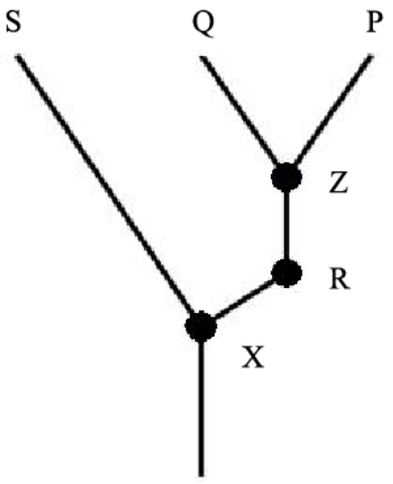
Answer **all** the questions.

1. Q, P, R and S are related species of organisms.

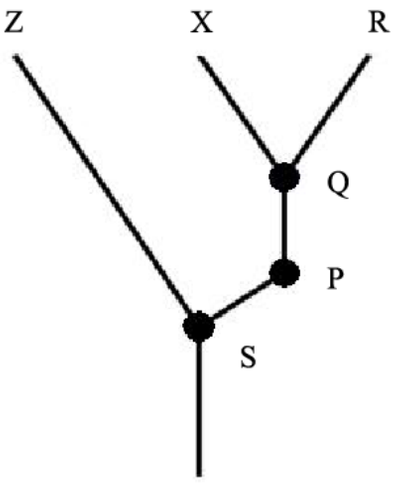
Species X is an extinct recent common ancestor of species Q and R.
X, Q and R all evolved from species P.
Species S is the least related to the others, with extinct species Z being its most recent phylogenetic link to the other species.

Which of the following phylogenetic trees correctly represents the relationships described above?

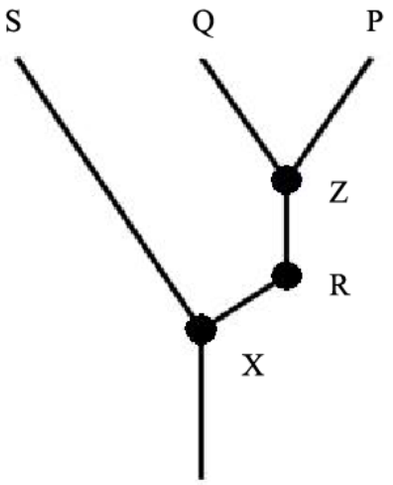
A



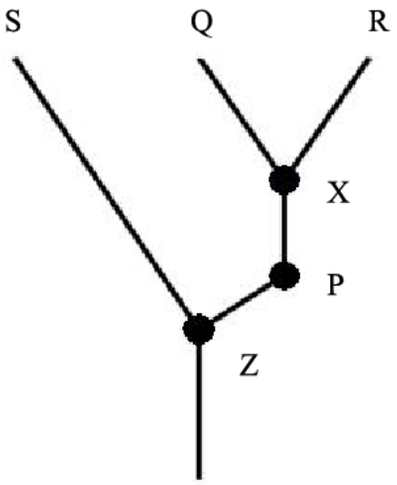
B



C



D



Your answer ☐

[1]

2. **Fig. 22.1** shows a transverse section of the stem of a typical pondweed viewed using a × 10 objective lens. Part of a graticule is shown below the stem. The markings on the graticule are 0.1 mm apart.

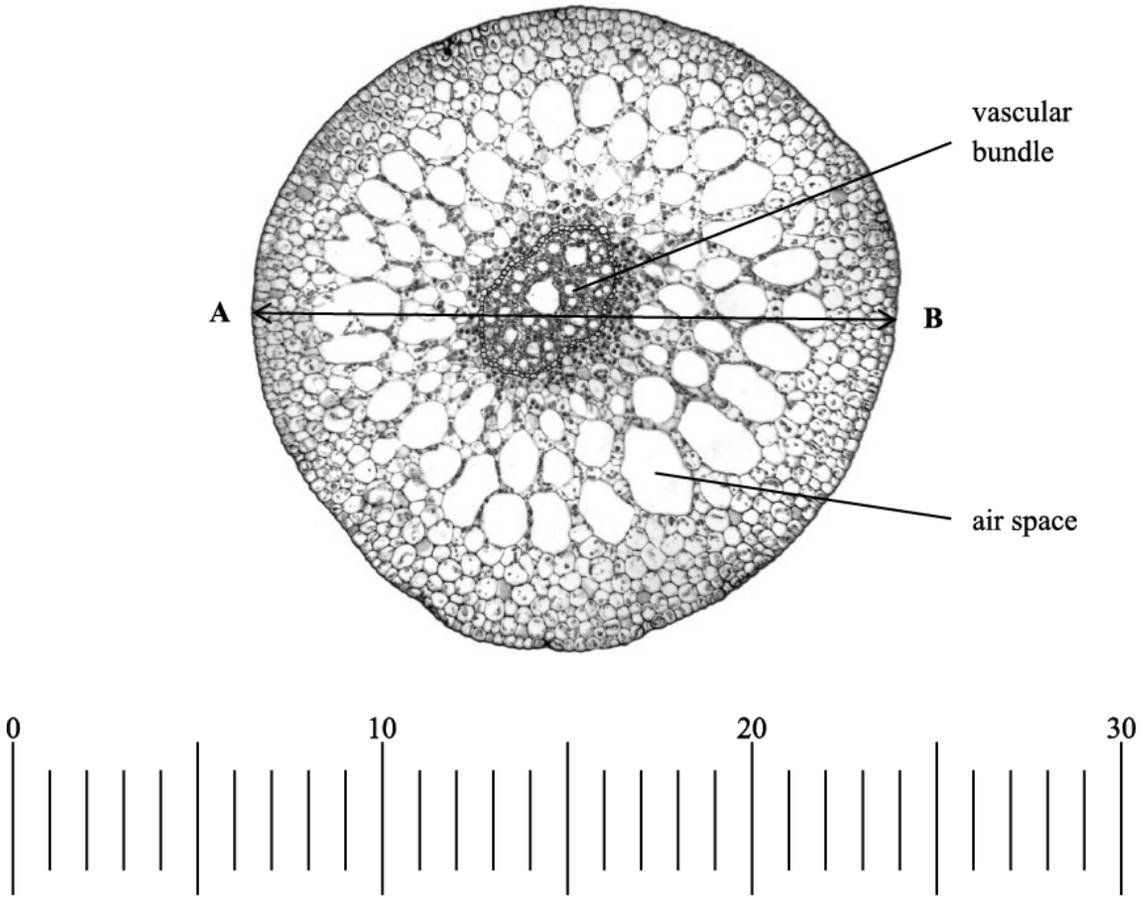


Fig. 22.1

(i) Measure the width of the stem between points **A** and **B**.
Give your answer to the nearest 0.1 mm.

Answer _____ **[1]**

(ii) Calculate the magnification of the image in **Fig. 22.1**.

Answer _____ **[2]**

(iii) The thin stem and thin cell walls do not provide much support for the leaf. Suggest how the leaf is supported.

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[2]

3. The table below shows features of the five kingdoms.

Kingdom	Nerves present	Hormones present
Prokaryotae	×	×
Protoctista	×	×
Fungi	×	□
Plantae	×	□
Animalia	□	□

Which of the statements, **A** to **D**, is correct?

A only autotrophic organisms require hormones
B only heterotrophic organisms need to interact with their environment
C only multicellular organisms require hormones
D only unicellular organisms require nervous systems

Your answer ☐

[1]

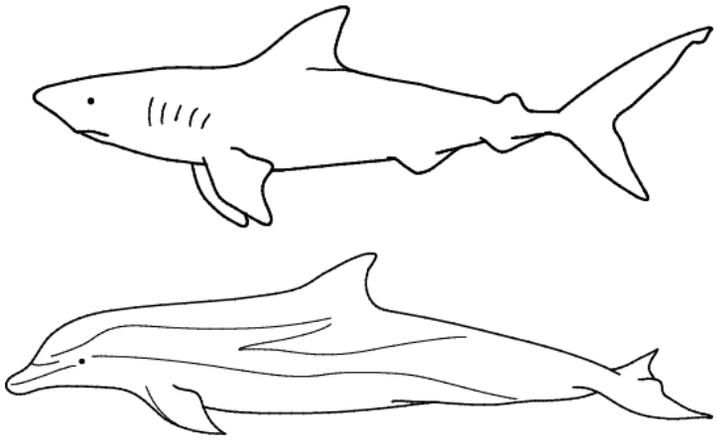
4. State **two responses** that some plants use to defend themselves from herbivory.

---

[2]

5. These two organisms show very similar anatomical adaptations but are classified in different taxonomic groups.

shark (fish)



dolphin (mammal)

What is this an example of?

A convergent evolution
B divergent evolution
C disruptive selection
D stabilising selection

Your answer ☐

[1]

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6.

(i) It takes time for an effective vaccine to be prepared in quantity for a new strain of bacterium.

List two vulnerable groups of people for whom you would advise doctors to prescribe antibiotics although they are **not** yet showing symptoms of the new disease.

---

[2]

(ii) Discuss the implications of the over-use of antibiotics when people do not show symptoms.

---

[4]

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7. Domesticated pigs are descended from *Sus scrofa,* sometimes called the 'wild boar'.

(i) In **Table 17.1**

- number the levels in the correct sequence and
- complete the name column.

Sequence of levels	Level	Name
_____	Order	Artiodactyla
_____	Species	_____
_____	Family	Suidae
1	Kingdom	_____
_____	Genus	_____
_____	Phylum	Chordata
_____	Class	Mammalia

Table 17.1

[4]

(ii) We now have DNA evidence of how organisms are related to each other. This evidence has helped biologists to construct a second classification viewpoint: the Domain system.

Explain what such developments show about the nature of scientific knowledge.

---

[1]

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8. * Read the following five statements.

Mutations preventing lactose intolerance have occurred in humans at various times in the prehistoric past, and in all human races.
The domestication of large lactating mammals like goats and cattle arose in Europe and parts of Africa 5 000 to 10 000 years ago.
The lowest levels of lactose intolerance are found in areas that European populations colonised, like North America.
The ability of agricultural populations to digest the milk, as well as the meat, of animals, is advantageous. It adds to their general nutrition.
Until recent times the Australian aborigines had been isolated on their island continent for around 50 000 years.

Suggest how the lactose intolerance phenotype came to be present in only 5% of a population like the Europeans, but came to be present in 97% of the Australian aborigines. Use the information given above and knowledge of Darwin's theory of evolution by natural selection.

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[9]

9. The European corn borer moth, *Ostrinia nubilalis,* is a pest of agriculture. Its larvae develop inside maize stems and eat the contents, weakening the stems so that the plants collapse.

The bacterium *Bacillus thuringiensis* ('Bt') produces a protein that poisons the larvae of moths and butterflies. This protein can be isolated from cultures of Bt and packaged in fluids to be sprayed on the surface of plants.

The gene coding for the toxic protein has also been isolated. It has been incorporated into a genetically modified strain of maize called Bt corn. This makes the plant tissues poisonous to the corn borer moth.

Consider the statement:

'Genetically modified plants and animals should be classed as new species'.

Outline **one** experiment or investigation that would provide evidence to support or contradict the statement.

---

[3]

10(a). Bats are the only mammals that have wings. Many species of bat hunt flying insects at night. Bats are able to use echolocation (sound waves) in order to help them find their prey in the dark.

(i) Explain why bats and birds, despite not being closely related, have both evolved wings.

---

[3]

(ii) Suggest why the vast majority of bird species have not evolved the ability to echolocate.

---

[1]

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(b). * The pipistrelle is the most common species of bat in Europe.

Table 5.1 shows information about two distinct populations of pipistrelle.

Population	Mean body mass (g)	Mean wingspan (m)	Range of echolocation call (kHz)	Colour	Habitat
Common pipistrelle	5.5	0.22	52 – 60	medium to dark brown	woodland, hedgerows, grassland, farmland, suburban and urban
Soprano pipistrelle	5.5	0.21	42 – 47	medium to dark brown	wetland, woodland edge, tree lines, hedgerows, suburban gardens and parks

Table 5.1

A researcher made the following claim:

'*The common pipistrelle and soprano pipistrelle must be distinct species.*'

Evaluate the researcher's claim by using the evidence in **Table 5.1** to support and to challenge the researcher's conclusion.

[6]

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11(a). Evolution is the change of species over time. Natural selection is the mechanism by which this change occurs.

Fig. 1.1 shows two species of trilobites, a group of arthropods that became extinct about 240 million years ago. Species **A** is 20 million years older than species **B**.

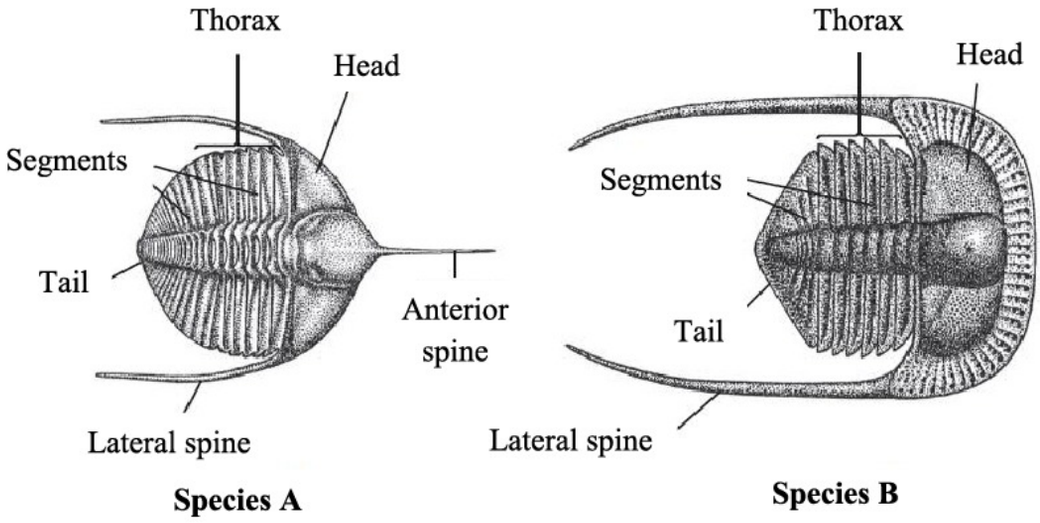


Fig 1.1

(i) Explain how scientists are able to estimate the age of extinct organisms, such as species **A** and species **B**.

_____

_____

_____

_____ **[2]**

(ii) Identify two features **visible** in both species that suggest that species **A** and species **B** evolved from a relatively close common ancestor.

1 _____

2 _____

[1]

(iii) A student used Fig. 1.1 to make a number of observations comparing species **A** and **B**.

One such observation was “species **B** had longer lateral spines than species **A**”.

Explain why this is not a valid observation to make on the basis of Fig. 1.1.

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_____

_____

_____ **[2]**

(iv) Fig. 1.2 shows two modern arthropods.

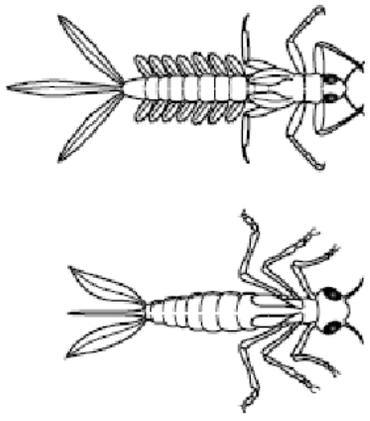


Fig. 1.2

Modern species **C** and **D** live in water. The trilobite species, **A** and **B** also lived in water.

Identify and briefly explain an adaptation present in all four species, **A**, **B**, **C** and **D**, that would be advantageous for an organism that lives in water.

Adaptation _____

Explanation _____

[1]

(b). Explain how biological molecules can provide evidence that species have evolved.

You should refer to different types of molecule in your answer.

---

[4]

(c). In his book 'On the Origin of Species', Charles Darwin made the following four observations.

E Offspring generally appear similar to their parents.
F No two individuals are identical.
G Organisms have the ability to produce large numbers of offspring.
H Populations in nature tend to remain relatively stable.

From these observations he made a number of deductions, listed in the table below.

The deductions are supported by one **or more** of the observations (**E**, **F**, **G** or **H**).

In the table, indicate which of the above observations contributed to each deduction.

You may use each letter (**E**, **F**, **G**, or **H**) once, more than once, or not at all.

Deduction	Supporting observation(s)
Characteristics are passed on to the next generation.	
There is a struggle for existence.	
Individuals with beneficial characteristics are among the few who survive.	

[3]

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12. Which statement, **A** to **D**, best describes the relationship between classification and phylogeny?

A classification and phylogeny are the same thing
B modern classification reflects phylogeny
C phylogeny is the science used in classification
D phylogeny is naming the phyla used in classification

Your answer ☐

[1]

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13(a). Fig. 20.1 shows a transmission electron micrograph of part of a eukaryotic cell.

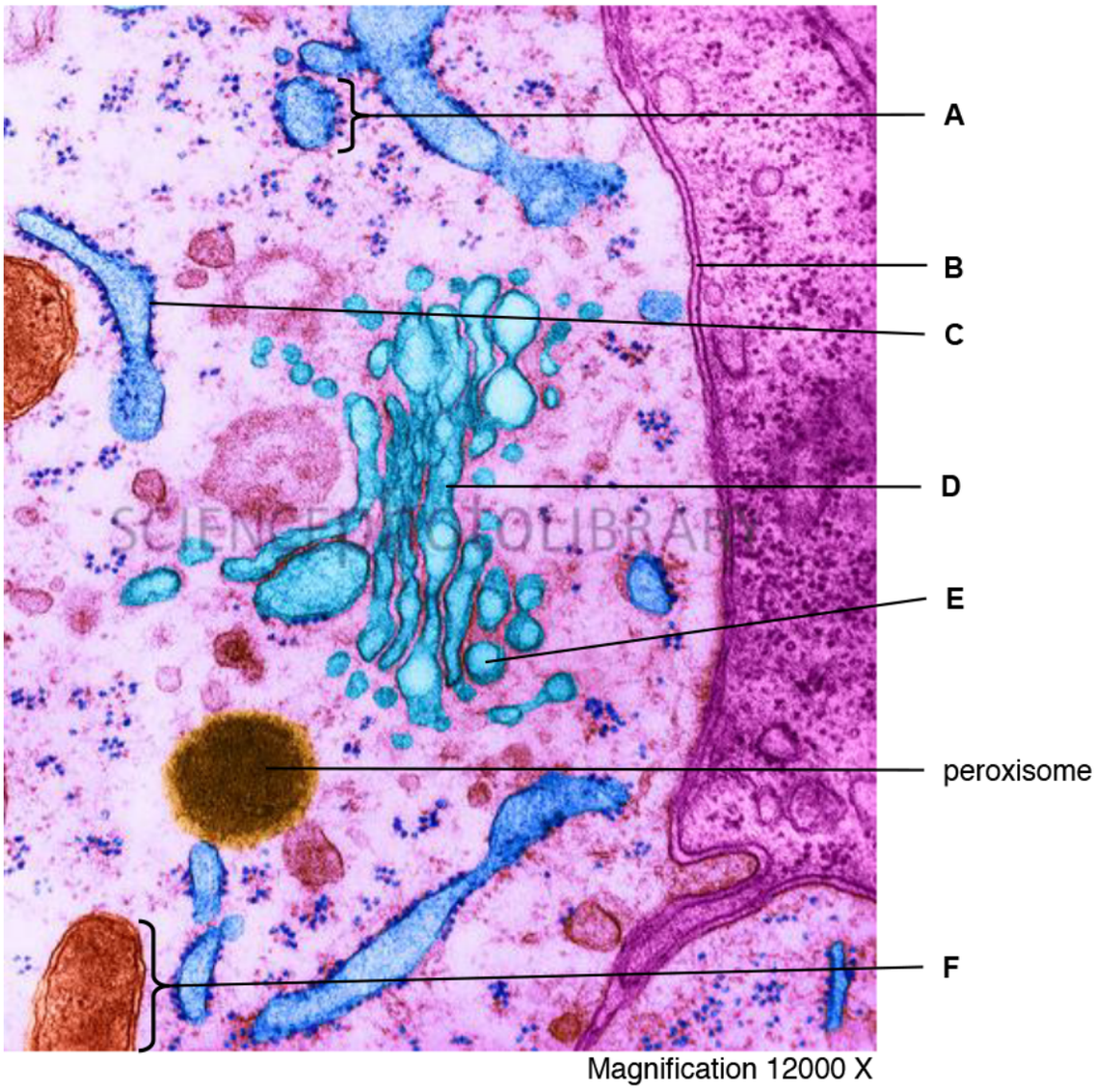


Fig. 20.1

(i) Identify **one** feature inside the cell that would also be seen in a prokaryotic cell.

_____ **[1]**

(ii) Identify **two** features of this cell that confirm it is **not** a prokaryotic cell.

In each case state the letter and the name of the feature.

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*Letter.*__________ *Name*____

*Letter.*__________ *Name*____

[2]

(b). The cell shown in **Fig. 20.1** is capable of synthesising and secreting proteins.

Using **only** the letters from **Fig. 20.1**, list the correct sequence of the organelles involved in synthesis and secretion of a protein.

____

____ **[3]**

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14(a). Termites are highly social insects. They are thought to have evolved from earlier forms of insect at least 150 million years ago, in the Jurassic geological period. They are related to cockroaches.

(i) How might scientists a century ago have known that termites evolved in the Jurassic geological period?

---

[1]

(ii) What new source of evidence might help today's scientists to find out how closely related termites are to cockroaches?

---

[1]

(b). **Fig. 5.1** shows a termite mound, the nest of approximately one million individuals. The photograph was taken in Queensland Australia, about 3000 kilometres south of the equator.

(i) **Fig. 5.1** shows that the interior of the termite mound is full of interconnecting chambers. At the top of the mound some of these chambers open to the air outside.

Worker termites spend all their time working in brood chambers low in the mound, where eggs and larvae develop.

Explain how carbon dioxide produced in the respiring body cells of worker termites is removed to the air outside the termite mound.

---

[4]

(ii) In Africa, closer to the equator, the mounds built by some species of termite are blade-shaped, with the long axis pointing North–South. **Fig. 5.2** shows an example of a termite mound in Africa.

Suggest why the African termites need to build mounds in this shape and orientation.

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[2]

Fig. 5.1



Fig. 5.2



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15. Which of the following options, **A** to **D**, lists the three domains of life?

A Archaea, Bacteria and Eukaryota
B Bacteria, Prokaryota and Eukaryota
C Prokaryotae, Protoctista and Eukaryota
D Protoctista, Plantaea and Animalia

Your answer

[1]

16. Halophytes are plants that have the ability to live in soils with a very low water potential. In the UK these plants form part of salt marsh communities.

Suggest **and** explain how the root hairs of halophytes are able to absorb water by osmosis from the soil of the salt marsh.

[2]

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17(a). The Sumatran rhinoceros, *Dicerorhinus sumatrensis*, is a rare member of the family Rhinocerotidae. These rhinoceros are now critically endangered, with only six substantial populations in the wild: four in Sumatra, one in Borneo, and one in the Malay Peninsula.

D. sumatrensis lives in rainforests. Their numbers are difficult to determine but they are estimated to number fewer than 100.

Complete the table below, showing the classification of the Sumatran rhinoceros.

Kingdom	_____
Phylum	Chordata
_____	Mammalia
_____	Perissodactyla
Family	Rhinocerotidae
_____	Dicerorhinus
Species	_____

[2]

(b). The name *Dicerorhinus sumatrensis* is part of the binomial naming system.

State an advantage of using this system rather than using the common name, Sumatran rhinoceros.

---

[1]

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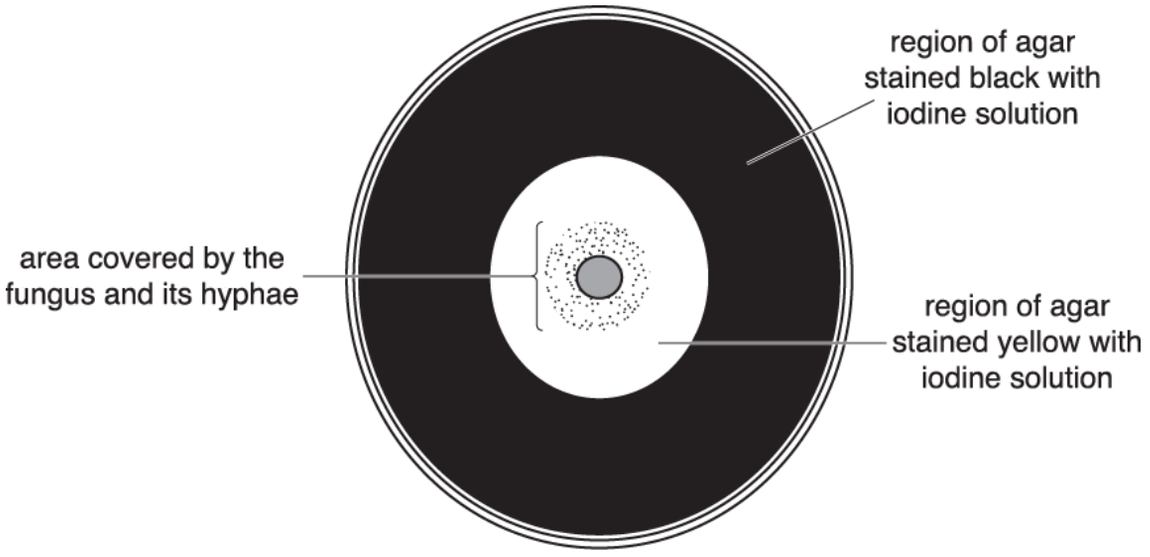
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18. Fungi produce enzymes to digest complex food substances. Amylase is an enzyme that catalyses the conversion of starch to maltose.

- A sample of the fungus *Amanita citrina* was placed on agar in a petri dish.
- The agar contained starch.
- The dish was incubated until the thread-like hyphae had grown a few centimetres.
- Iodine solution was then poured onto the surface of the agar.

A diagram representing the results is shown in the figure.



(i) To which genus does this fungus belong?

---

[1]

(ii) The region of yellow staining shown in the figure includes part of the agar where the fungus had not yet grown.

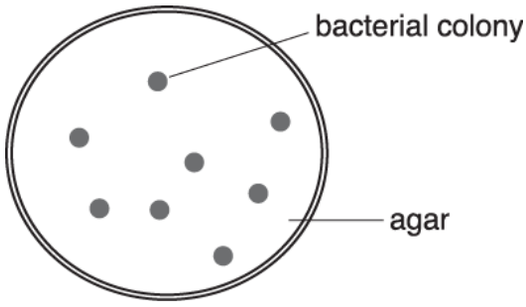
What does this pattern indicate about the action of the fungal enzymes?

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[1]

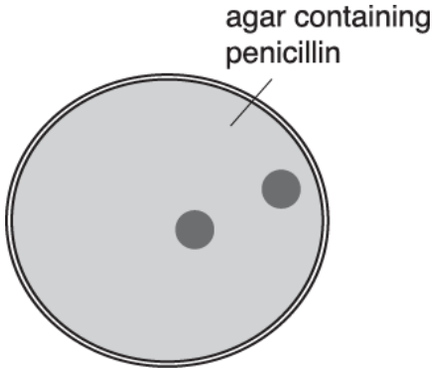
19(a). An experiment was carried out to investigate the resistance of a species of bacterium to the antibiotic penicillin.

Bacteria were allowed to grow into colonies on an agar plate.

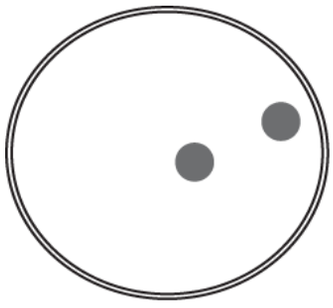


A cloth was placed onto the bacteria and then the pattern of bacterial colonies was transferred to an agar plate that contained penicillin.

Only two colonies survived and continued to grow on the agar that contained penicillin.
The bacteria in these colonies possessed a mutation that gave them resistance to the penicillin.



The original plate was flooded with a solution containing penicillin and the same two colonies continued to grow.



(i) A student made the following suggestion:

> I think that the colonies on the agar containing penicillin that survived and grew did so because those bacteria evolved resistance.
> They evolved resistance as a result of being exposed to the penicillin.

Another student commented:

But some of the bacteria in the population were already resistant, so they can't have evolved resistance because they were exposed to the penicillin.

What evidence indicates that the penicillin-resistant bacteria already existed in the population?

---

[1]

(ii) Name the process that increases the proportion of penicillin-resistant bacteria in the population.

---

[1]

(b). One role of the Office for National Statistics (ONS) is to collate data about the causes of death in England and Wales. Deaths involving *Staphylococcus aureus* and MRSA statistics have been produced by the ONS for each year since 1993.

S. aureus can be mentioned on a death certificate and *S. aureus* may also be specified as being methicillin resistant (MRSA).

Table 6 shows the data for the years 1993 to 2012.

Year	**Number of death certificates mentioning *S. aureus***		
	***S. aureus* not specified as resistant**	***S. aureus* specified as MRSA**	**Total**
1993	379	51	430
1994	358	90	448
1995	409	198	607
1996	445	298	743
1997	395	386	781
1998	451	409	860
1999	484	480	964
2000	476	666	1036
2001	473	731	1204
2002	421	794	1215
2003	448	968	1516
2004	461	1138	1599
2005	450	1649	2099
2006	498	1652	2150
2007	459	1593	2052
2008	270	1230	1500
2009	472	781	1253
2010	475	485	960
2011	274	364	638
2012	265	292	557

Table 6

(i) Calculate the percentage increase in the number of death certificates that mention MRSA from 1993 to the year when the numbers reach a peak.

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Show your working and give your answer to **three significant figures**.

Answer =_____ % **[2]**

(ii) The proportion of death certificates that mention MRSA in 1993 is 12%.

Compare this figure with the proportion of death certificates that mention MRSA in 2012.

---

[2]

(iii) What can you conclude from these data about the deaths involving S. aureus and MRSA since 2007?

---

[2]

20. *Nymphaea thermarum* is the world's smallest and most endangered water lily.
Individual *N. thermarum* plants measure 10–20 cm across.

Explain why the size of *N. thermarum* is an example of **continuous** variation.

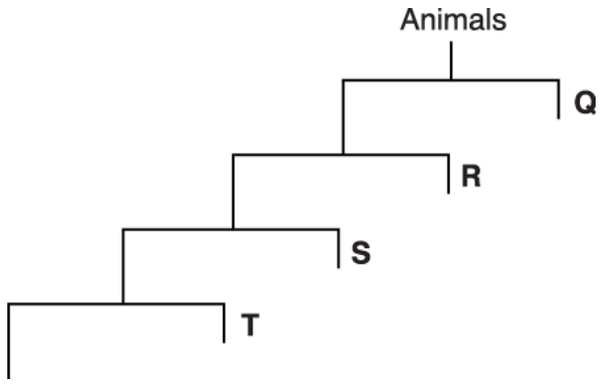
---

[3]

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21.

(i) The figure is a diagram representing the taxonomic hierarchy of organisms within the animal kingdom.



State the level of taxonomic group represented by the letters **Q, R, S** and **T.**

Q

R

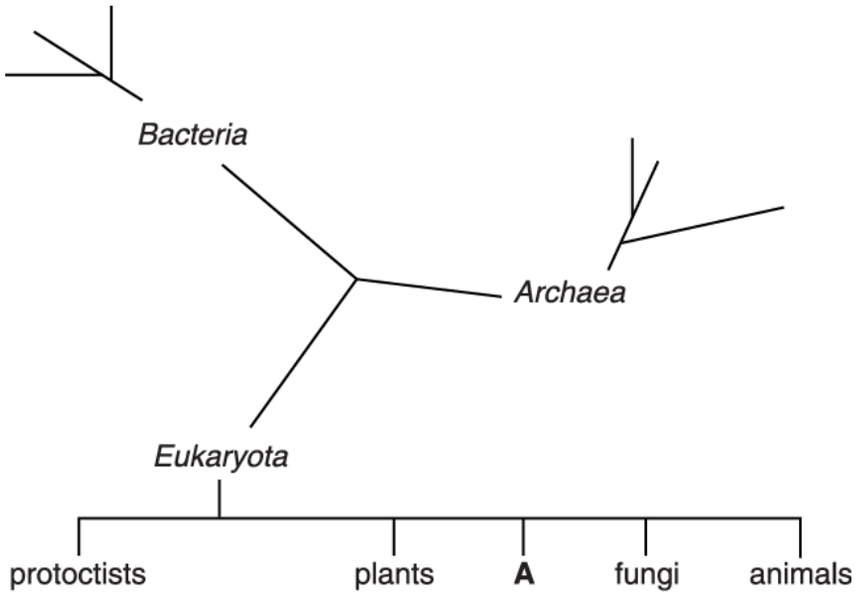
S

T

---

[2]

(ii) The figure shows a diagram representing the phylogenies of some groups of organisms.



The letter '**A**' on the figure represents a group of organisms called slime moulds.

With reference to the figure, discuss the classification of slime moulds and include the range of evidence on which this classification might be based.

---

[3]

(iii) State **three** reasons why the three-domain classification system is now used in preference to the five-kingdom system.

1

2

3

---

[3]

22. In the past, roe deer's main natural predator in Britain was a large carnivore of the cat family, the Eurasian lynx, *Lynx lynx*. The lynx became extinct in Britain around 1000 years ago.

Populations of Eurasian lynx still survive in parts of mainland Europe.

Plans are being considered to re-introduce the Eurasian lynx from these European populations to the wild parts of Britain to improve biodiversity.

(i) Suggest **one** reason why some people might object to this re-introduction.

---

[1]

(ii) A small population of Iberian lynx, *Lynx pardinus*, exists in parts of Spain. The Iberian lynx is critically endangered and, with around 100 individuals left, it is the world's most endangered species of cat.

The Iberian lynx and Eurasian lynx were once classified within the same species, based on their observable features.

In the last 10 years, the Iberian lynx has been re-classified as a separate species within the genus *Lynx*, on the basis of its phylogeny.

Define the term *phylogeny* and explain how phylogeny is related to classification. Use the two lynx species as examples.

---

[4]

(iii) Suggest why it is only in the last 10 years that the Iberian lynx has been classified as a separate species.

---

[1]

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(iv) Outline **three** reasons why it is important to conserve the Iberian lynx.

1

2

3

---

[3]

23. Complete the following passage by using the most appropriate terms.

Variation can be described as the differences in characteristics between _____. The type of variation that is caused by differences in DNA is known as _____ variation. Variation can also be caused by the _____. Variation between members of the same species is known as _____ variation. Evolution depends on variation and _____ of the best adapted individuals.

[5]

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24(a). In 2006, the scientific journal, Nature, reported the discovery of a fossil from around 380 million years ago. It was given the name *Tiktaalik roseae*.

This fossil has some features in common with fish and some features in common with amphibians.

A photograph of the fossil is shown in Fig. 1.1.



Fig.1.1

A diagram of the fossil viewed from above is shown in Fig. 1.2.

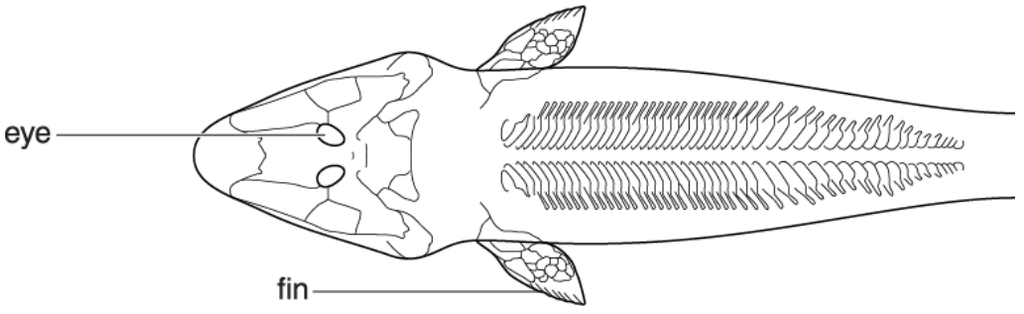


Fig.1.2

(i) Suggest **one** adaptation, **visible in Fig. 1.1 and Fig. 1.2**, which would be an advantage for life under water.

---

[1]

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(ii) Suggest **one** adaptation, **visible in Fig. 1.1 and Fig. 1.2**, which would be useful for an animal that lives on the sea bed.

---

[1]

(b). *Tiktaalik roseae* is a member of the kingdom Animalia. The structure of its individual cells has not been preserved by fossilisation.

State **two** features of cells of an organism from the kingdom **Plantae** that would **not** have been present in the cells of *T. roseae*.

1

2

---

[2]

(c). Fossils provide strong evidence that organisms have evolved over time.

Describe **other** types of evidence that support the theory of evolution.



In your answer you should describe some different types of evidence.

[6]

25. The Royal Botanic Gardens at Kew plays an important role in plant conservation. One plant that has been conserved at Kew is the world's smallest water lily, the thermal lily, *Nymphaea thermarum*.

In its natural habitat, the thermal lily grows in hot water springs in central Africa.

State the genus to which the thermal lily belongs.

---

[1]

26(a). Charles Darwin sailed on HMS Beagle on its voyage around the world between 1831 and 1836.

Darwin made the following observation:

'offspring generally appear similar to their parents'

State the conclusion that Darwin drew from this observation.

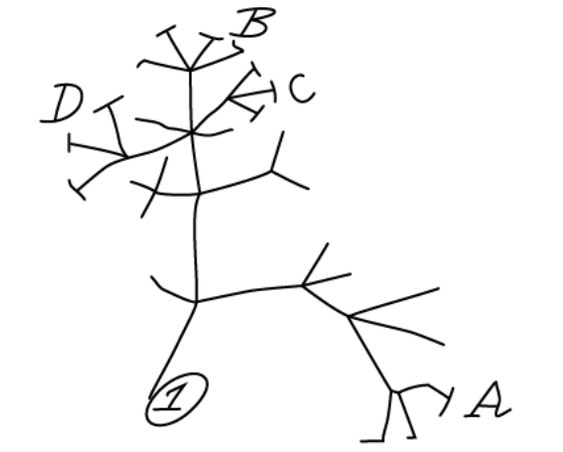
---

[1]

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(b). Shortly after the voyage, Darwin sketched a diagram in his notebook.

His sketch is shown in Fig. 5.1.



Charles Darwin (1837)

Fig.5.1

- A, B, C and D represent different modern day organisms.
- (1) represents an ancestral organism.

Explain what the sketch shows about the relationship between organisms A, B, C, and D.

---

[2]

(c). In 1859, Darwin published his book, *On the Origin of Species*, in which he explained how organisms evolve by natural selection:

- Darwin's book caused controversy at the time of its publication
- his theory of natural selection is now widely accepted by scientists.

Why is natural selection now more widely accepted by scientists than it was in the 19th century?

---

[1]

(d). During the voyage of HMS Beagle, Darwin visited the Galapagos Islands off the coast of South America.

He observed that many of the closely related species showed significant variation.

(i) State the name given to the evolution of a new species.

---

[1]

(ii) Suggest why a higher number of species have evolved in the Galapagos Islands, compared with an area of the same size on the South American mainland.

---

[1]

27. The term *immunity* is often used when describing how vaccines work.

In a piece of school homework a student wrote:

"Bacteria can evolve quickly and many are now immune to antibiotics."

Explain why the student's use of the word 'immune' was incorrect.

---

[3]

28. Discuss the ways in which genetic variation is produced, including the role of nuclear division.



In your answer you should link the processes to the ways in which the genetic variation is produced.

[9]

29(a). This question looks at two ways of using mathematical concepts in Biology.

When a new road system was constructed, it split a population of a rare snail species into three smaller populations, **A**, **B** and **C**. As a result, each of these populations became reproductively isolated.

The Hardy-Weinberg principle was used to calculate the relative frequencies, p and q, of a dominant and a recessive allele in each population.

Table 4.1 shows the values of p and q, and the estimated sizes of these three populations.

Snail population	Estimated population size	Immediately after road building		10 years after road building	
		p (frequency of dominant allele)	q (frequency of recessive allele)	p (frequency of dominant allele)	q (frequency of recessive allele)
A	1000	0.50	0.50	0.52	0.48
B	100	0.49	0.51	0.63	0.37
C	10	0.40	0.60	0.20	0.80

Table 4.1

(i) Name the type of isolating mechanism that prevents interbreeding between these three snail populations.

---------- **[1]**

(ii) The habitat of these snail populations did not change over the ten years.

State the term used to describe the **random** changes in allele frequency in a small population.

---------- **[1]**

(iii) Explain which of the populations, **A**, **B** or **C**, experienced most genetic change.

---------- **[2]**

(b). The inheritance of different alleles in fruit flies, *Drosophila* spp., has been studied extensively in the laboratory.

Two genes that affect the appearance of *Drosophila* are:

R / r	red / pink eyes
Y / y	yellow / ebony body

Flies known to be heterozygous at both of these loci were crossed with homozygous pink-eyed ebony flies.

Based on the hypothesis that the two genes assort independently, the offspring expected from this cross would be four different phenotypes in a ratio of 1:1:1:1.
The results obtained, however, are shown in Table 4.2.

Phenotype	**Expected number**	**Observed number**
Red eye, yellow body	360	6
Pink eye, yellow body	360	701
Red eye, ebony body	360	729
Pink eye, ebony body	360	4

Table 4.2

The chi-squared (χ^2) test can be used to assess whether the results in Table 4.2 are significantly different from the expected results.

The equation for working out the value of χ^2 is given below.

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

where $\sum$ = 'sum of …'
O = observed value
E = expected value

(i) Calculate the value of χ^2 **to the nearest whole number** for the genetic cross results shown in Table 4.2.

Complete the table below and determine the value of χ^2.

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Phenotype of fly	O – E	$(O - E)^2$	$\frac{(O - E)^2}{E}$
Red eye, yellow body	–354	125316	348
Pink eye, yellow body	341	116281	323
Red eye, ebony body			
Pink eye, ebony body			

χ^2 = _____

[3]

(ii) Statistical tables show that, for this data set, if χ^2 has a value of 11.35, the observed results would only be produced by chance in 1% of trials.

Use this information and the value for χ^2 that you have calculated in **(i)** to explain whether the original hypothesis should be accepted or rejected.

_____

_____

_____**[1]**

(iii) The difference in the observed numbers from the cross compared with the expected numbers has **not** occurred by chance. Suggest a genetic explanation for this difference.

_____

_____

_____

_____

_____

_____

_____

_____**[3]**

30. Nicotine is produced by plants of the genus *Nicotiana*.

In an experiment, the leaves of a *Nicotiana* plant were punctured with tiny holes. This damage imitated insect attack.

Table 7.1 shows the effect of this damage on the nicotine concentration and seed production of a *Nicotiana* plant compared with a plant that was not damaged.

	Nicotine concentration (%)	**Number of seeds produced**
Control plant	0.67	2600
Plant with leaves punctured with holes	0.98	1100

Table 7.1

Discuss whether the ability to produce nicotine can be considered a selective advantage or a selective disadvantage to *Nicotiana* plants.

---

[3]

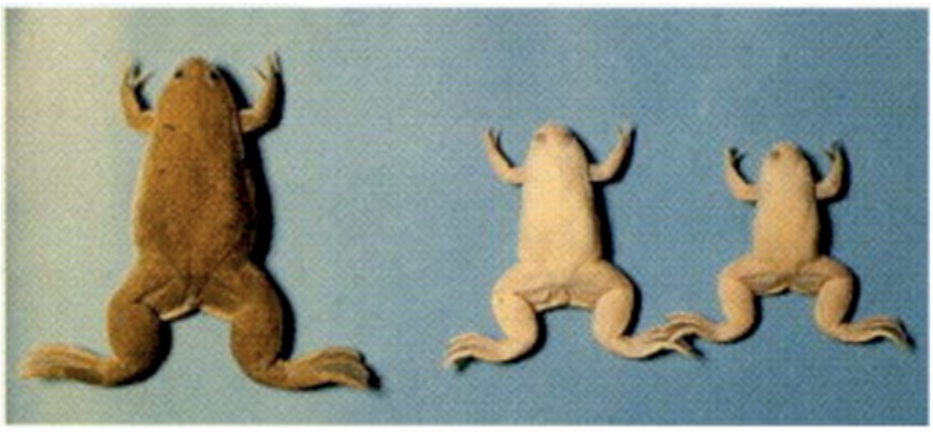
31. In 1958, scientists made a breakthrough in artificial reproductive cloning by successfully cloning a vertebrate species. The species cloned was the African clawed frog, *Xenopus laevis*.

Fig. 1.1, shows the cloned offspring produced, labelled **D**, as well as the three adult frogs (**A**, **B** and **C**) that were used to create them.

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A B C



D

Fig. 1.1

- frog **A**, a brown-coloured female frog, laid eggs, which then had their nuclei removed.
- frog **B**, an albino (white-coloured) female, laid eggs that were fertilised by sperm from **C**.

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- frog **C**, an albino male, produced sperm that fertilised the eggs of **B**.

One of the fertilised eggs from **B** was allowed to divide. Nuclei were extracted from the resulting cells and placed into the eggs from frog **A**. These eggs developed into the frogs labelled **D** in Fig. 1.1.

(i) The frogs in Fig. 1.1 show discontinuous variation in colour.

Using your knowledge of discontinuous and continuous variation, and the information given, suggest:

one other phenotypic characteristic in which the frogs show a discontinuous pattern of variation

---

one phenotypic characteristic in which they show a continuous pattern of variation.

---**[2]**

(ii) State the extent to which the environment is likely to affect each of the phenotypic characteristics that you have suggested in **(i)**.

---**[2]**

(iii) Suggest why albino frogs were used to produce the nuclei for transfer.

---**[2]**

32(a). *Bombus pratorum* and *Bombus terrestris* are two British species of bumble bee.

These bumble bees are social insects. They live in colonies founded by a female queen bee who lays eggs. The eggs develop into female worker bees, who collect food (nectar and pollen) and look after the young and the nest.

When the number of worker bees starts to decrease, young queens and males are produced. These mate and the mated queens survive winter underground and start a new colony the following spring.

Why do the two bee species share the first name *Bombus*?

---

[1]

(b). Fig. 2.1 shows the number of worker bees of *B. pratorum* and *B. terrestris* observed at one location over a year.

Table 2.1 shows some differences in the food collecting behaviour of worker bees of these species.

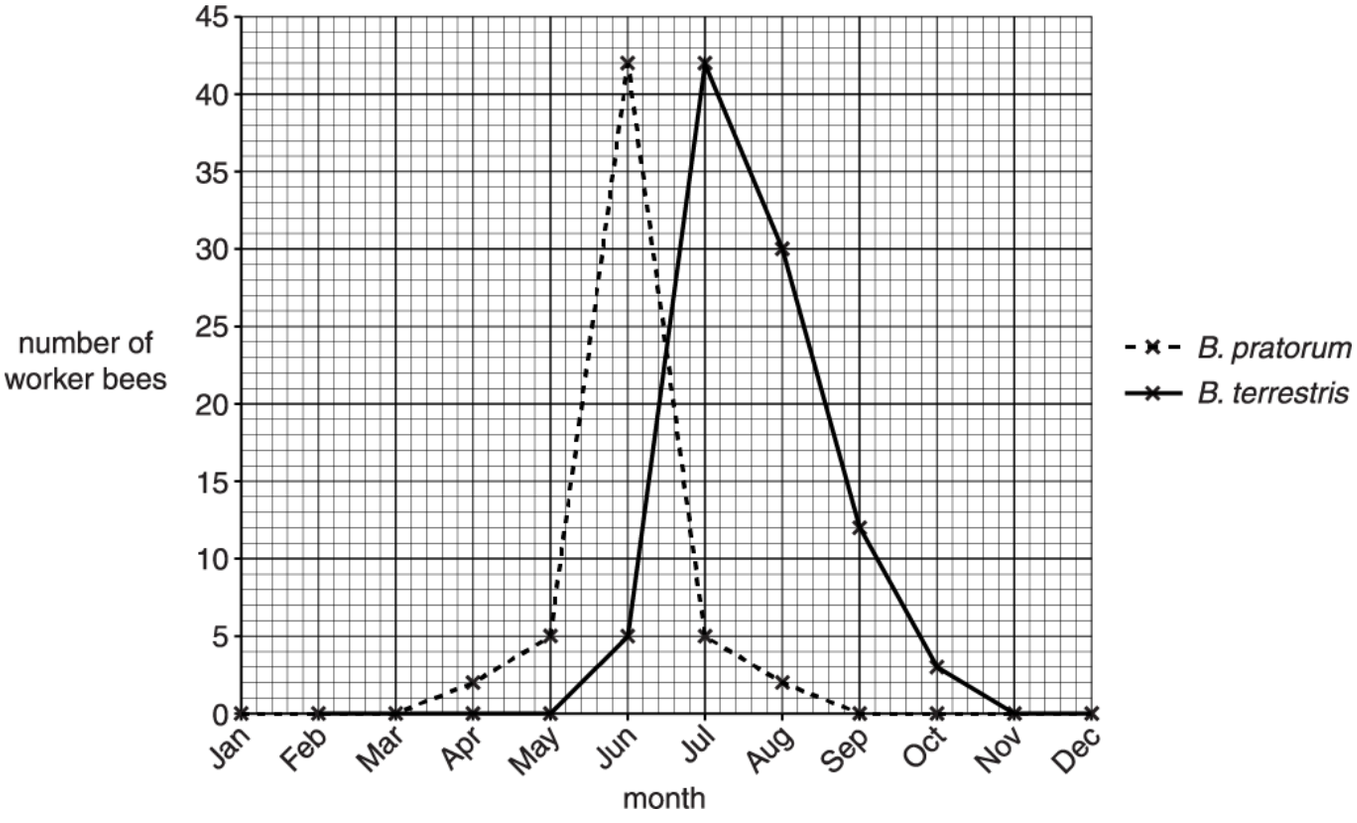


Fig. 2.1

Species of bumble bee	Mean depth of flower visited (mm)	Visits to flowers when nectar only collected (%)	Visits to flowers when pollen only collected (%)	Visits to flowers when both nectar and pollen collected (%)
Bombus pratorum	7.4	23	10	67
Bombus terrestris	6.3	80	11	9

Table 2.1

(i) *B. pratorum* and *B. terrestris* both live in Britain. They can often be found in the same location, as their geographical distributions overlap.

Use Fig. 2.1 and Table 2.1 to evaluate the extent to which the two species may compete.

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[4]

(ii) Use Fig. 2.1 and Table 2.1, and the information given on page 7, to suggest how an ancestral species might have evolved into the two species, *B. pratorum* and *B. terrestris*.

[3]

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(c). Bees show a variety of interesting behaviour patterns.

(i) Consider the following observations about bee behaviour and suggest what type of behaviour is being shown in each observation.

Observation	Type of behaviour
The time taken for a worker bee to collect food from a flower decreases with practice.	
All bumble bees start at the bottom of a vertical spike of flowers and work upwards.	

[2]

(ii) On returning to the colony, worker bees perform 'dances' to tell other bees the direction and distance of a food source.

How might this social behaviour benefit the colony?

---

[1]

33. Which of the statements, **A** to **D**, does **not** provide evidence for natural selection?

A Clover plant populations produce higher hydrogen cyanide toxin levels in areas where snails are common.

B Fossils of animals identical to species living today can be found in shallow rocks.

C Insects can rapidly develop resistance to insecticides such as DDT.

D Resistant forms of *Staphylococcus aureus* were not known before 1961.

Your answer ☐

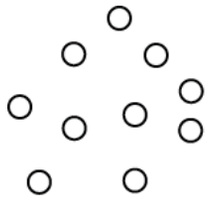
[1]

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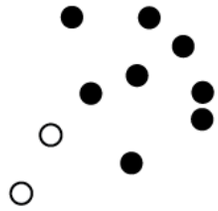
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34. Diagrams **X**, **Y** and **Z** represent populations of microorganisms.



X



Y



Z

Which of the sequences, **A** to **D**, demonstrates the changes caused by addition of a drug to which some individuals are resistant?

A Y, X, Z
B Z, Y, X
C Z, X, Y
D Y, Z, X

Your answer

[1]

35(a). As an extension to the field work the student decided to investigate the effect of soil moisture on the germination of buttercup seeds.

The student planted *R. bulbosus* seeds into five pots and maintained the soil moisture in each pot at a different level (0%, 20%, 40%, 60% and 80%). This was repeated with seeds of *R. repens*. After four weeks the student counted the number of plants that had germinated in each pot.

Table 16 shows the results of the student's investigation.

Soil moisture (%)	**Number of seedlings germinated**	
	R. bulbosus	*R. repens*
0	0	0
20	23	8
40	46	15
60	16	42
80	4	33

Table 16

(i) State **two** factors that should be controlled as part of this investigation.

1

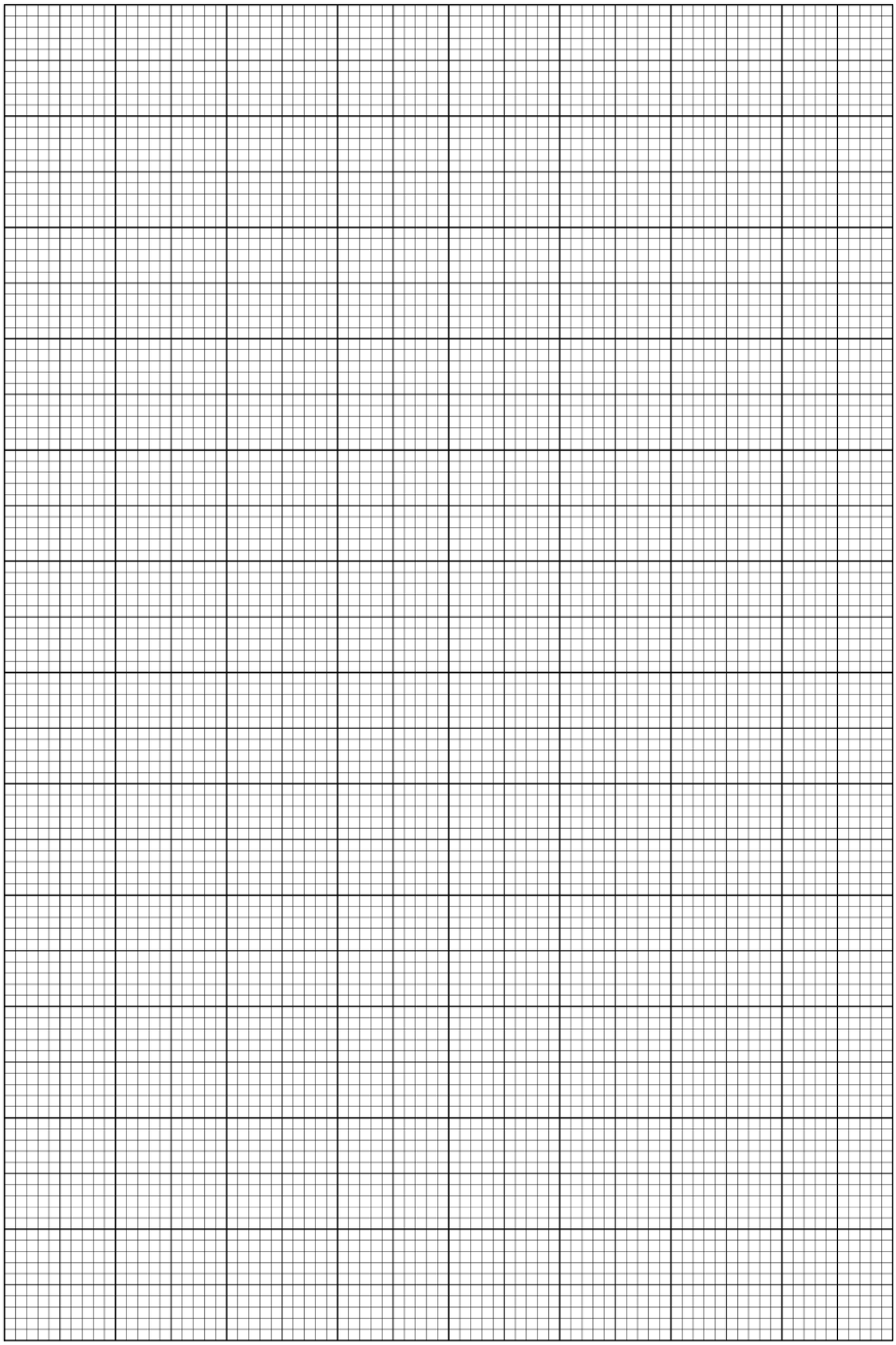
2

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[2]

(ii) Use the grid provided on page 13 to plot the results of this investigation.

[4]



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(b). The student used Spearman's rank correlation to show that germination is correlated to soil moisture in *R. repens*.

The value of Spearman's rank correlation coefficient (r_s) is calculated using the formula:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

where d is the difference in rank within each pair and n is the number of pairs.

(i) Use the following table to calculate the value of Σd^2.

Soil moisture (%)	**Rank (R1)**	**Number of seedlings germinated**	**Rank (R2)**	**d (R1–R2)**	**d^2**
0	1	0	1	0	0
20	2	8	2	0	0
40	3	15	3	0	0
60	4				
80	5				
				Σd^2	

[2]

(ii) Use your value of Σd^2 to calculate the value of r_s.

r_s = _____ **[2]**

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(iii) The critical value at p = 0.05 is 1.0.

What can the student conclude about the correlation between soil moisture and germination in *R. repens*?

---

[1]

36(a). Squid are an order of aquatic animals. Many species of squid show a reflex response to changes in their body position.

- A sensory receptor called a statocyst detects changes in the body position of the squid in their aquatic environment.
- The reflex response corrects the squid's body position.

(i) Describe the components and events involved in a reflex arc.

---

[3]

(ii) Suggest one benefit to the squid of the reflex response described above.

---

[1]

(iii) A statocyst sensory receptor is shown in Fig. 2.1.

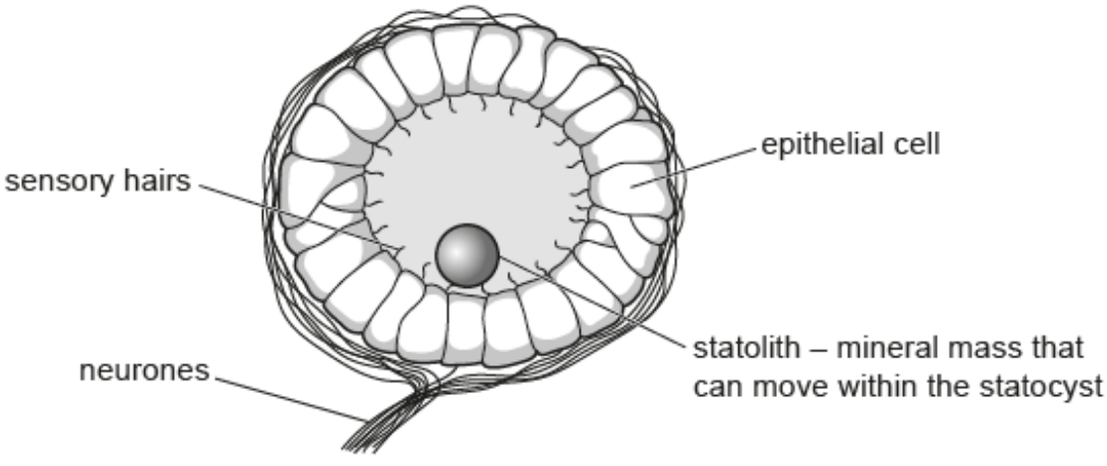


Fig. 2.1

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What can you conclude from Fig. 2.1 about the mechanism by which a statocyst acts as a transducer?

---

[3]

(b). Lobsters and sea cucumbers also have statocysts. From this information, the student concluded:

'I think this means squids, lobsters and sea cucumbers evolved from a recent common ancestor and are probably classified in the same phylum.'

Evaluate the extent to which the information about lobsters and sea cucumbers supports the student's conclusion.

---

[2]

END OF QUESTION PAPER

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Question			Answer/Indicative content	Marks	Guidance
1			D	1	
			Total	**1**	
2		i	1.7 mm (1)	1	
		ii	× 50 (1)(1)		**ALLOW** 1 mark for correct working e.g. 80 / 1.6 **ALLOW** answer in the range of 48–51
		iii	air spaces give buoyancy (1) supported by (surrounding) water (1)	2	
			Total	**5**	
3			C	1	
			Total	**1**	
4			(named) chemicals (1) folding (1) stings (1)	2	**ALLOW** 2 named chemicals
			Total	**2**	
5			A	1	
			Total	**1**	
6		i	*two from* babies / infants (1) elderly / infirm (1) immuno-compromised / on immunosuppressant drugs / HIV positive (1) known to have been exposed (to the infection) (1)	2	

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td></td><td>ii</td><td>two from
(antibiotic is) selective pressure (1)
(bacterial) gene pool / AW, has variation (1)
(only) some bacteria have resistance / some bacteria are more resistant than others (1)
two from
when exposed (to antibiotic) most-resistant survive (1)
surviving bacteria continue to reproduce to make a resistant population (1)
idea that over many generations there is an increase in proportion of resistant bacteria (under continued antibiotic pressure) (1)
antibiotic becomes ineffective / new antibiotic needed (1)</td><td>4</td><td>IGNORE increase in number of resistant bacteria.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td></td></tr>
<tr><td>7</td><td></td><td>i</td><td><table><tr><th>Sequence of Levels □</th><th>Level</th><th>Name</th></tr><tr><td>4</td><td>Order</td><td>Artiodactyla</td></tr><tr><td>7</td><td>Species</td><td>scrofa □</td></tr><tr><td>5</td><td>Family</td><td>Suidae</td></tr><tr><td>1</td><td>Kingdom</td><td>Animal(ia) □</td></tr><tr><td>6</td><td>Genus</td><td>Sus □</td></tr><tr><td>2</td><td>Phylum</td><td>Chordata</td></tr><tr><td>3</td><td>Class</td><td>Mammalia</td></tr></table></td><td>4</td><td>One mark for level numbers all correct in Column 1.

DO NOT ALLOW if scrofa is given capital S.

ALLOW "Animals“

DO NOT ALLOW if Sus is given lower-case initial s.</td></tr>
<tr><td></td><td></td><td>ii</td><td>science knowledge / it, advances / improves / grows / AW (1)</td><td>1</td><td>"Develop“ is in the question.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>5</td><td></td></tr>
</table>

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Question			Answer/Indicative content	Marks	Guidance
8			* **Level 3 (7–9 marks)** Extensive reference has been made to the (pre-) historical circumstances of both populations. Inferences have been clearly drawn in terms of natural selection. Learner demonstrates a holistic grasp of the Darwinian theory and the information given; reaching reasoned conclusions that explain how the different phenotypic frequencies occurred. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (4–6 marks)** Reference has been made to the (pre-) historical circumstances of both populations. Some inferences have been drawn in terms of natural selection. There is partial structuring of the ideas with the connections between Darwinian theory and information generally clear. Conclusions are used to explain how the different phenotypic frequencies occurred. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–3 marks)** Reference has been made to the (pre-) historical circumstances of at least one of the populations. At least one inference has been stated in terms of natural selection. The ideas expressed are poorly structured but some relevant points are made. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of	9	**Indicative scientific principles may include:** **Europeans:** • (pre-agricultural) gene pool / genetic variation, included mutant / non-intolerance, allele • availability of milk acted as (positive) selection pressure • individuals / groups, with mutant / non-intolerance, allele had better, chance of survival / success in reproduction • directional selection • mutant / non-intolerance, allele accumulated (in gene pool) • genetic drift (in small prehistoric population) • mutant / non-intolerance, allele is dominant • so expressed in heterozygotic individuals (increasing phenotype frequency). **Australian aborigines:** • ancestral population pre-agricultural • so no selection for mutant / non-intolerance, allele • no suitable mammals to domesticate / milk • island, so no borders for suitable mammals to come in • no contact / breeding, with non-Aboriginal peoples • no gene flow (from other human populations) • no selection pressure • to increase mutant / non-intolerance, allele / phenotype, frequency.

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Question			Answer/Indicative content	Marks	Guidance
			credit.		
			Total	**9**	
9			*Fertility* breed GM stock with non-modified stock (1) see if offspring fertile (1) if so they should be classed as the same species (1) **ora** *Morphology* Compare several individuals from GM and non-GM groups (1) in respect of several physical structures (1) if similar they should be classed as one species (1) **ora** *Ecology* observe how both function in the wild (1) occupy the same or different niche(s) (1) if same niche they should be classed as one species (1) **ora** *Genetics* compare DNA (1) by electrophoresis (1) same pattern should be classed as one species (1) **ora**	3	Marks awarded should be from **one** outlined investigation **and** the conclusion from its results. If more than one investigation suggested, mark the first investigation and **IGNORE** the others.
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
10	a	i	*three from* similar, niche / lifestyle / AW (1) similar selection pressure (1) *idea that* wings are advantage for survival in both bats and birds (1) alleles for 'wings' more likely to be passed to next generation (1)	3	**ALLOW** 'same' **ALLOW** 'same' **ALLOW** 'genes'
		ii	*idea that* echolocation not needed for an animal active during the day where reduced visibility is not an issue (1)	1	

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Question			Answer/Indicative content	Marks	Guidance
	b		* **Level 3 (5–6 marks)** Full and detailed evaluation of the claim using all of the data in Table 5.1. Learner demonstrates a holistic judgement of the data providing evidence for and against the claim. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Detailed evaluation of the claim using most of the data in Table 5.1. Sound judgement is made on a range of aspects of the data. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** An evaluation of the claim is attempted using some of the information in Table 5.1. Simple conclusions are drawn citing limited aspects of the data. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	6	**Indicative scientific points may include:** **Support for conclusion (that common and soprano pipistrelle are distinct species)** • echolocation ranges do not overlap • genetic basis for echolocation suggests genetic difference between populations • idea that different species are likely to have genetic differences. **Information that could be used in support or to challenge** • Mean wing span is very similar • Could indicate difference, though not significant • Could be due to environmental factors, where the populations live • Habitats overlap • Could indicate same species in different areas • Could be different species adapted to slightly different environments. **Challenge to conclusion** • same mean body mass, could be same species • same colour, could be same species • potential environmental cause of body mass variation implies weak challenge to conclusion. **ALLOW** a comment on whether the researcher's conclusion is supported.
			Total	**10**	

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Question			Answer/Indicative content	Marks	Guidance
11	a	i	fossils (1) *idea that* fossils deeper in the ground are older than those near the surface (1)	2	**ALLOW** reference to radiometric dating **IGNORE** refs to carbon dating as time-scale is too great
		ii	Any two from similar tail segments lateral spines (1)	1	
		iii	no scale given on figure (1) *idea that* comparison in absolute length cannot be made (1) *idea that* comparison in relative length (compared with body length) could be valid (1) maturity / age, of specimen unknown (1) *idea that* only one individual of each species observed (1)	2	
		iv	*adaptation and explanation must both be present to be awarded the mark* tail for, swimming / movement (1) **OR** segments, for flexibility / moving tail / swimming (1)	1	**ALLOW** streamlined shape for movement in water
	b		*biological molecule* nucleic acid / (nuclear) DNA / mtDNA / RNA (1) *idea that* in samples from two species sequence similarity in any of the above can imply an evolutionary relationship, difference / divergence in sequence implies evolutionary distance (1) *biological molecule* proteins / polypeptides / cytochrome C / haemoglobin (1) *idea that* in the same protein from two species, amino acid / primary sequence similarity implies evolutionary relationship, difference / divergence in sequence implies evolutionary distance (1)	4	**ALLOW** named proteins commonly used

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<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>c</td><td></td><td>
<table>
<tr><th>Deduction</th><th>Supporting observation(s)</th></tr>
<tr><td>characteristics are passed on to the next generation</td><td>E (1)</td></tr>
<tr><td>there is a struggle for existence (1)</td><td>G and H</td></tr>
<tr><td>individuals with beneficial characteristics are among the few who survive</td><td>F and G and H (1)</td></tr>
</table>
</td><td>3</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>13</td><td></td></tr>
<tr><td>12</td><td></td><td></td><td>B</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>13</td><td>a</td><td>i</td><td>C / ribosomes</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>ii</td><td>Any two from:

A rough endoplasmic reticulum
D Golgi apparatus
E secretory vesicle
F mitochondrion (1)(1)</td><td>2</td><td></td></tr>
<tr><td></td><td>b</td><td></td><td>C/A then D then E (1)(1)(1)</td><td>3</td><td>letters must be in correct order, if not all correct:
allow one mark if C/A as first letter given
allow one mark for E as last letter given
allow one mark for D in the middle

IGNORE B as this is plasma membrane rather than an organelle</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td></td></tr>
</table>

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Question			Answer/Indicative content	Marks	Guidance
14	a	i	fossils in, known-age / Jurassic, strata / rocks	1	
		ii	DNA / cytochrome c	1	
	b	i	carbon dioxide diffuses down concentration gradient out of the respiring cell (1) carried through body from cell (to tracheoles) by blood passing out via tracheoles / trachea / spiracles (1) respiration generates heat (1) hot gases expand and are less dense so rise up by convection through the mound to vents at mound-top (1)	4	
		ii	*shape,* large or increased surface area to volume ratio (1) smallest area exposed to greatest heat (1)	2	Response **must** be linked to context of avoiding overheating / needing to get rid of heat.
			Total	**8**	
15			A	1	**Examiner's Comments** There is some evident confusion with taxonomy. Despite many candidates choosing the correct option, D was a common suggestion.
			Total	**1**	

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Question			Answer/Indicative content	Marks	Guidance
16				2	**IGNORE** ref to large surface area and short diffusion path **IGNORE** ref to solute potential / isotonic **ACCEPT** Ψ for water potential 'it' or 'they' = root hairs **IGNORE** ref to roots or root cells unqualified as hairs
			there is a lower water potential inside root hair (cells) ☐		**ACCEPT** root hair, has / creates, a lower water potential (than soil) **ACCEPT** maintains / sets up / establishes, a (steep) water potential gradient Look for a comparison in water potential between the cell and the soil
			actively transport / pump, (mineral) ions / salts, into root hair(s) (cells) **or** root hair(s) (cells) store / contain, (mineral) ions / salts / solutes ☐		**IGNORE** solutes / sugars / hydrogen ions **ACCEPT** named ions **ACCEPT** named ions **ACCEPT** named solutes e.g. sugars
					Examiner's Comments This question highlighted the failure of many candidates to use the correct scientific terminology. In particular was the use of 'concentration gradient' without showing an appreciation of, or even mentioning, water potential, despite the previous parts of the question being on that subject. Where active transport was mentioned some thought it was the water that was pumped into the cell or that transpiration was also involved. Many candidates understood the principal of reducing the water potential of the root hair cells but failed to gain credit by referring to the roots or the plant without specifying the 'root hair cells'.They also talked about the large surface area of root hair cells, which also failed to gain credit.
			Total	**2**	

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Question			Answer/Indicative content	Marks	Guidance
17	a		*Column 1* *Column 2* Class Animalia Order Genus ☐ *sumatrensis* ☐	2	*If additional incorrect answer given, then 0 marks* One mark per correct column. **ACCEPT** Animal / phonetic spelling / in lower case 'sumatrensis' must be all in lower case **DO NOT CREDIT** if the 's' is clearly upper case **DO NOT CREDIT** D. sumatrensis **DO NOT CREDIT** Sumatran / sumatran **Examiner's Comments** In the classification table the categories of taxa were correctly stated by the majority but the actual classification groups within the taxa posed more problematical☐ in particular identifying 'Animalia' as the correct kingdom. Eukaryota was a common error. Although many candidates correctly stated the species as 'sumantrensis', very many were not credited the mark because of using a capital letter.
	b		universal / recognised worldwide / AW ☐ know which, genus / species, it belongs to ☐ *idea of* different common name for the same organism ☐	max 1	**ACCEPT** no language barrier **ACCEPT** ref to showing evolutionary relationships (e.g. shows common ancestry) **Examiner's Comments** Most candidates stated that the advantage of the binomial naming system is that it is used as a universal language and therefore avoids confusion over different common names for the same organism.
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
18		i	*Amanita* ☐	1	First letter must be a capital, the rest must be lower case. **Examiner's Comments** Most candidates selected the correct name and wrote it with a capital letter.
		ii	*one from* 1 (starch) digestion in the regions where the, fungus / hyphae, not present ☐ 2 *enzymes / they, are* released / diffuse away, from the fungus **or** extracellular / secreted ☐	1	1 **ACCEPT** breaks down (starch) in the, region / area / agar, around the fungus **Examiner's Comments** It was surprisingly rare for candidates to apply their knowledge of kingdom Fungi to realise that digestion here is extracellular, involving enzymes being secreted by the hyphae and acting outside of them. Some referred to 'it' and their subsequent answer did not make it clear whether the answer referred to the enzymes or the fungus.
			Total	**2**	

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Question			Answer/Indicative content	Marks	Guidance
19	a	i	*idea that* the third diagram shows that the resistant, bacteria / colonies, were already present (on the original plate) **or** these (resistant) bacteria on the original plate continued to grow when flooded with penicillin ☐	1	**IGNORE** penicillin will kill them so in order for them to survive the mutation must have already happened **IGNORE** no time for natural selection to take place – as these are explanations and not evidence **Examiner's Comments** Most candidates found this question challenging, tending to repeat or rephrase the stem of the question. Vague or ambiguous references to being exposed to penicillin were insufficient as they needed to clearly refer to the original colonies that survived when the original petri dish was flooded with penicillin. The candidates needed to take careful note of the diagrams and the information provided in order to make an informed statement.
		ii	natural <u>selection</u> ☐	1	**CREDIT** directional <u>selection</u> **IGNORE** evolution / survival of the fittest / binary fission / mutation **Examiner's Comments** This question elicited the following incorrect answers on a frequent basis: binary fission, mutation, evolution and mitosis. Some misunderstood the question and referred to antibiotic resistance, immunity or vaccination.

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Question			Answer/Indicative content	Marks	Guidance
	b	i	3140 □ □	2	**Correct answer = 2 marks**, even if no working shown. • If the answer is incorrect or has not been rounded to 3 sig. figs., then **award 1 mark** for seeing **either** $\frac{1652 - 51}{x}$ or $\frac{1601}{x}$ where x = any number **or** an unrounded answer (e.g. 3139.2156 or 3139) • If the incorrect peak has been chosen, then **award 1 mark only for a correct answer which is correctly expressed to 3 sig. figs.** Using 1649 the correct answer is 3130 Using 1593 the correct answer is 3020 **Examiner's Comments** Candidates should be encouraged to always show their working for calculations. Those who did were frequently able to be awarded a mark for working despite having the incorrect answer. Most were able to select the correct figures but were unable to manipulate them correctly. Calculation of percentage increase, decrease or change proves to be challenging for candidates.

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Question			Answer/Indicative content	Marks	Guidance
		ii	was lower (in 1993) **or** has increased / is higher (in 2012) □ *(in 2012)* 52% or 0.52 □	2	**IGNORE** ref to raw data **ACCEPT** 'over 4 x greater in 2012' **ACCEPT** 52.4% **Examiner's Comments** In contrast, most candidates performed this calculation correctly and were able to make a suitable comment relating to its increase since 1993.

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Question			Answer/Indicative content	Marks	Guidance
		iii	*two of* 1 (trend is) decrease in (number of) deaths (since 2007) ☐ 2 consistent / steady / large / dramatic, decrease in (deaths from *S. aureus* specified as) MRSA (from 2007) ☐ 3 ref to better specific cross-infection control measure in health care ☐ 4 any correct processed data comparing either years or cause of death using figures from table 6 ☐	2	**IGNORE** raw data quotes 2 *idea that* non-specified fluctuates **Note** 'a large decrease in the number of deaths from MRSA' = 2 marks (mps 1 & 2) 3 e.g. isolating MRSA cases / dress code for health professionals / hygiene measures / pre operation screening 4 *MRSA* e.g. decrease of, 1301 / approx. 260 per year 2012 value is, 18.3% / approx. 20% / approx. ☐, of 2007 value a drop of, 82% / approx. 80%, from 2007 to 2012 *total* e.g. decrease of, 1495 / approx. 39 per year 2012 value is, 27.1% / approx. 25% / approx. ¼, of 2007 value a drop of, 73% / approx. 70% / approx. 75%, from 2007 to 2012

Year	% death certificates mentioning *S. aureus*		Total number of death certificates mentioning *S. aureus*
	S. aureus not specified as resistant	*S. aureus* specified as MRSA	
2007	22 or 22.4	78 or 77.6	2052
2008	18	82	1500
2009	38 or 37.7	62 or 62.3	1253
2010	49 or 49.5	51 or 50.5	960
2011	43 or 42.9	57 or 57.1	638
2012	48 or 47.6	52 or 52.4	557

Examiner's Comments

Most candidates observed the correct trend but did not clearly distinguish between total certificates mentioning *S. aureus*, those mentioning *S. aureus* specified as MRSA and those mentioning *S. aureus* not specified as resistant. Data quoted was frequently raw data rather than processed. Measures to prevent cross-infection were only credited if they were specific rather than vague references to 'better hygiene'.

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Question			Answer/Indicative content	Marks	Guidance
			Total	**8**	
20			range of, values / intermediates; quantitative; influenced by environment; influenced by more than two genes / polygenic;	3 max	**ACCEPT** no distinct, categories / groups **ACCEPT** (sketch of) normal distribution / bell-shaped curve **IGNORE** 'can be measured' **ACCEPT** example, e.g. those with more access to nitrate could grow larger **Examiner's Comments** This was generally done well. All marking points were seen but the most common mark was for reference to a range of values or the lack of discrete categories.
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
21		i	Q phylum / phyla R class S order T family;	2	If any answer is wrong **AWARD** max 1 if the other 3 taxa are correct If Q is wrong **AWARD** max 1 if all stated taxa are in the correct **consecutive** sequence **Q IGNORE** phylus **Examiner's Comments** Candidates who were aware of the classification hierarchy tended to get both marks, whereas those who didn't tended to make wild guesses, often referring to vertebrates and invertebrates or even mammals, birds and amphibians. Some got the wrong starting point, not realising that 'kingdom' had been given in the stem of the question.
		ii	**1** eukaryotes / in eukaryote domain; **2** (classified on the basis of) genetics / amino acid sequences; **3** genetics / observable features / amino acid sequences, distinct from other, (eukaryotic) kingdoms; **4** genetics / amino acid sequence, less similar to, protoctists **or** genetics / amino acid sequence, more similar to, plants / fungi;	4	**ACCEPT** 'genes / DNA / RNA / base sequences / proportion of bases' as AW for genetics **4 IGNORE** observable features for this marking point **4 IGNORE** animals **Examiner's Comments** About half of all candidates managed to say that slime moulds must be eukaryotic. Few candidates scored more than one. Those few candidates who achieved full marks did so by addressing marking point 1 and 4, which automatically meant they were awarded marking point 2 as well. Generally, most statements were about cell walls and chloroplasts, rather than DNA or amino acid sequences. Marking point 3, which was key to the context of the question, was rarely awarded.

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Question			Answer/Indicative content	Marks	Guidance
		iii	**1** *idea that* 3 domains fits phylogeny better; **2** (there are) key / many / fundamental / important, differences between, bacteria / prokaryotes, **and**, eukaryotes / other (4) kingdoms; **3** eukaryotes all have, nucleus / membrane-bound organelles / 80S ribosomes; **4** (there are) key / many / fundamental / important, differences between bacteria and archaea; **5** bacteria and archaea have different, cell membrane / flagella / (named) enzymes / transcription / DNA replication / RNA;	3 max	**1 ACCEPT** e.g. classifies species that are more closely related together / it is a better representation of the true relationship / reflects evolutionary history better **1 IGNORE** clearer **1 IGNORE** reference to common ancestors **2 ACCEPT** there are fundamental similarities between the 4 eukaryotic kingdoms that are not shared with prokaryotes **4 ACCEPT** 'there are good reasons why prokaryotes should be split' **4 ACCEPT** 'bacteria and archaea are more different that we thought' **Examiner's Comments** Few candidates scored marks in (iii), and where marks were awarded they tended to be for citing and, more often, exemplifying key differences between bacteria and archaea. Some came close to marking point 4 but stated only that bacteria and archaea were different with no suggestion that these differences were significant enough to justify a change in the classification system. Many candidates appeared to be offering a mark scheme from a previous, but fundamentally different, question on the same topic. Candidates who achieved no marks often made vague statements about it being simpler, easier to use, or more accepted.
			Total	**8**	

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Question			Answer/Indicative content	Marks	Guidance
22		i	*idea of* danger to, humans / local wildlife / domestic animals / deer; environment may no longer be suitable for lynx / AW;	1	**ACCEPT** *idea of* danger to existing food chains **IGNORE** could become a pest **IGNORE** dangerous without further qualification **IGNORE** competition **Examiner's Comments** The vast majority of candidates were able to access this mark with little problem. The minority who did not gain the mark discussed the lynx out-competing the native species or bringing disease into the country.

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Question			Answer/Indicative content	Marks	Guidance
		ii	1 (phylogeny is) the evolutionary, relationship between / history of, organisms / species; 2 phylogeny is the basis of classification; 3 example of molecular evidence used to classify; 4 species / organisms, within the same group have shared, phylogeny / evolutionary history / common ancestor; **ora** 5 *idea that* phylogeny of *L. lynx* and *L. pardinus* are sufficiently, different to have been placed in separate species / similar to have been placed in same genus;	4 max	**1 ACCEPT** reasonable description of evolutionary, history / relationship, e.g. changes in ancestral organisms **2** Must be a clear statement **3 ACCEPT** base sequence / amino acid sequence / DNA / cytochrome C / haemoglobin / ATPase (used to classify) **Examiner's Comments** Candidates found this question challenging and it discriminated well between candidates of different abilities. Many students had learnt the definition of phylogeny and gained the first marking point. Definitions that failed to get a mark usually failed to mention evolution or species. Few candidates stated that phylogeny was the basis of classification with sufficient weight or clarity to gain a mark. A minority of candidates were able to gain ab mark by stating that certain biomolecules were used in classification as an indicator of phylogeny. The general marking point 4 was awarded even less often than the more specific marking point 5. Candidates tended to simply re-iterate the stem of the question without mentioning the lynx's phylogeny. Some candidates had the idea of marking point 5 but failed to use the term either species or genus and so could not be awarded the mark.

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Question			Answer/Indicative content	Marks	Guidance
		iii	modern / new / better, technology (to distinguish between closely related species); more, molecular / biochemical / DNA / genetic, evidence;	1	**ACCEPT** named example, e.g. DNA sequencing **Examiner's Comments** Most candidates gained the mark for new/better technology or reference to biochemical evidence. The most disappointing wrong answer, seen quite frequently, was that the lynx had recently evolved into a new species over a 10 year period.
		iv	1 *idea of* impact on food chain(s); 2 *idea of* right to exist / duty of humans to care for other species / ethical reason / preserving species for future generations; 3 *idea of* aesthetic reason; 4 economic reason / tourism / might provide useful resource;	3 max	**1 ACCEPT** controlling deer population **1 ACCEPT** top carnivore / top predator / keystone species / it might compete with existing species **1 IGNORE** other species might die **2 IGNORE** 'playing God' **2 IGNORE** refs to poaching / hunting **3 ACCEPT** beautiful creatures / nice to look at / AW **Examiner's Comments** The vast majority of candidates gained at least 2 marks on this sub-question and many scored all 3. A variety of answers were allowed and the candidates offered a range of, often ingenious, valid responses ranging from the lynx possibly having useful hormones or enzymes to being of national significance to the heritage of Spain. The most frequently offered non-creditworthy answers referred to maintenance of biodiversity or genetic variation, or to prevent extinction.
			Total	**9**	

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Question			Answer/Indicative content	Marks	Guidance
23			1 individuals / organisms / species / phenotypes; 2 genetic; 3 environment; 4 intraspecific; 5 selection / survival;	5	**Mark the first answer.** If the answer is correct and another answer is given that is incorrect or contradicts the original answer, then = **0 marks** **IGNORE** offspring **ACCEPT** inherited / genetical **IGNORE** named example of environment, e.g. diet **ACCEPT** intraspecies **ACCEPT** breeding / reproduction **ACCEPT** natural selection / survival of the fittest **Examiner's Comments** Four marks were usually awarded for this question. The most common incorrect response was where 'intraspecific' should have been. Many candidates wrote 'interspecific', 'continuous', or left it blank. A minority of candidates wrote 'speciation' or 'characteristics' in the last space.
			Total	**5**	

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Question			Answer/Indicative content	Marks	Guidance
24	a	i	fins; streamlining / streamlined shape;	1 max	**Mark the first answer**. If the answer is correct and another answer is given that is incorrect or contradicts the original answer, then = **0 marks** **ACCEPT** reasonable attempt to describe streamlined shape **ACCEPT** aerodynamic **ACCEPT** articulated / flexible, spine **Examiner's Comments** Almost all candidates answered this correctly, usually for writing 'fins'. A few responses mentioned gills but these were not visible in the diagram and so no mark was given.
		ii	eyes on top of head;	1	**Mark the first answer**. If the answer is correct and a further answer is given that is incorrect or contradicts the correct answer then = **0 marks** **ACCEPT** the position of the eyes / eyes that can see above **IGNORE** eyes facing forward **IGNORE** fin **IGNORE** eyes close together **IGNORE** refs to shape **Examiner's Comments** Around a third of candidates got a mark for referencing the position of the eyes on top of the head. Responses that mentioned eyes alone were not awarded a mark as the presence of eyes did not necessarily facilitate life on the sea bed. References to a flat belly were also not credited because the underside of *Tiktaalik* was not visible in the figures.

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Question			Answer/Indicative content	Marks	Guidance
	b			2	**Mark the first answer on each prompt line**. If the answer is correct and another answer is given that is incorrect or contradicts the original answer, then = **0 marks**
			1 (cellulose) cell wall;		
			2 chloroplast(s);		**2 CREDIT** plastids / dictysomes / many small Golgi **3 IGNORE** chlorophyll
			3 (large / permanent) vacuole;		**3 CREDIT** tonoplast
			4 starch granules;		**4 CREDIT** druses / raphides / crystalline inclusions / Ca oxalate
					Examiner's Comments Most candidates scored both marks. Popular answers were ‘cell wall’, ‘chloroplasts’ or ‘vacuole’. A few candidates wrote that they were autotrophic, failing to realise that the question asked for features present in cells.

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Question	Answer/Indicative content	Marks	Guidance
c	**1** (similarities / differences in) genes / genetics / DNA / RNA / molecules / biochemistry; **2** (similarities / differences in) nucleotide / base, sequence / order; **3** (similarities / differences in) cytochrome c / haemoglobin / ATP synthase / RNA polymerase; **4** (similarities / differences in) sequence / order, of amino acids (in proteins);	5 max	**1 ACCEPT** molecular / biochemical evidence
	5 *idea that* similarities between any of the above implies (close) relationship; **ora**		**5 CREDIT** if their genes are similar they must share a regmtcommon ancestor **5 AWARD** as a general statement or with an example, e.g. 'chimps and humans share large proportion of DNA and this means that they are related gets mp **1** and **5**.' 'Chimps and humans are closely related' = 0 marks unless linked to a marking point from 1 – 4.'
	6 *idea of* evolution within human history;		**6 CREDIT** in the context of an example of evolution in action, e.g. MRSA resistance to antibiotics **or** as a general statement **6 CREDIT** selective breeding (artificial selection) example
	7 similarities in / differences in / comparison of, embryology / morphology / anatomy / physiology / behaviour;		**7 CREDIT** e.g. similar finches occupying different niches on neighbouring Galapagos islands **7 CREDIT** e.g. vertebrate pentadactyl limb etc. **7 ACCEPT** idea of vestigial organs; **7 IGNORE** appearance / features / adaptations
	QWC; One mark from 1-4 and 1 mark from 6-7	1	Marking point **5** is not part of QWC **Examiner's Comments** Most candidates were able to gain 2-4 marks on this question; 5 marks were scored by a reasonable minority but only rarely were full marks awarded. A large proportion of answers referred to DNA, genetics or molecules, and many used cytochrome C, base sequence and/or amino acid sequence too. Quite a number of students successfully communicated the

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Question			Answer/Indicative content	Marks	Guidance
					idea that similarities in any of these biochemical features indicated a close relationship. However, candidates that chose to refer to a common ancestor as a signifier of similarity were not awarded marking point 5 on that basis alone. The term 'common ancestor' does not, in itself, signify a close relationship as all species, it could be argued, have a common ancestor. It was common for candidates to discuss humans and apes as an example of genetic similarity but discussion of this example often failed to clearly reference the idea of a close relationship between the two and sometimes confused apes with monkeys. Discussion of extraction of DNA from fossils or 'ancestral species', which was seen occasionally despite the question stem, was not credited. Only around a third of responses mentioned non-biochemical evidence; moreover, several candidates who did discuss non-biochemical evidence failed to mention molecules; hence the QWC was rarely awarded. A reasonable minority of responses discussed Darwin's finches but some were too vague to get a mark – referring to birds in general, for example. Comparison of anatomy and behaviour in general terms was seen in less than a quarter of answers but was usually credited when discussed. Reference to pentadactyl limbs was also credited where it was seen. Very few candidates, much fewer than expected, gained marking point 6. Those that were successful discussed antibiotic resistance in bacteria, insecticide resistance in malaria or the peppered moth. A number of candidates thought that phylogeny itself was evidence for evolution, suggesting a misunderstanding of either the term 'phylogeny' or the term 'evidence'. A few candidates, ignoring the question, wrote about fossils or the process of natural selection and were not given any credit.
			Total	**10**	

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Question			Answer/Indicative content	Marks	Guidance
25			Nymphaea;	1	**NOTE**: the first letter must clearly be in upper case and the others in lower case and the spelling correct **Examiner's Comments** The vast majority of responses were correct. Very few failed to correctly write '*Nypmhaea*' with a capital 'N'. The most common incorrect responses were '*thermarum*' and '*Plantae*'.
			Total	**1**	

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Question			Answer/Indicative content	Marks	Guidance
26	a		characteristics / features / AW, are passed on to / inherited (by the next generation);	1	**IGNORE** genes / alleles / DNA as question asks about Darwin's conclusion **ACCEPT** 'appearance' for features **DO NOT CREDIT** answers that only refer to beneficial characteristics (as Darwin's other observations would need to be considered to arrive at this conclusion) **Examiner's Comments** The question tested candidates' ability to link an observation with a reasonable conclusion. Most candidates discussed the inheritance of something. However, those that discussed only genes failed to get the mark because there was no information about genes in the observation. A few responses discussed inheritance of beneficial characteristics, but in order to draw this conclusion a further observation would have needed to be considered.

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Question			Answer/Indicative content	Marks	Guidance
	b			2 max	**IGNORE** references to relationship with organism (1)
			1 B **and** C **and** D are more closely related (to each other than to A); **ora**		**1 IGNORE** 'B, C and D are more similar' as this could refer to appearance rather than relationship
			2 *idea that* A is in different (taxonomic) group (from other 3); **ora**		**2 CREDIT** named taxonomic group
			3 B **and** C **and** D, share more, recent common ancestor;		**3 IGNORE** genes etc.
			4 phylogeny / evolution, of B **and** C **and** D diverged at same point; **ora**		**Examiner's Comments** Around half of responses gained 1 mark, usually for identifying the closer relationship, or more recent common ancestry, of B, C and D. Marking points 2 and 4 were rarely awarded. Responses that discussed a timescale got no credit and those that thought that C and D were somehow more related to each other than they were to B clearly misunderstood the nature of an evolutionary tree diagram. A minority of responses spent some time discussing the relationship between organism 1 and organisms A, B, C and D for no credit, as this is not what the question had asked them to do.

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Question			Answer/Indicative content	Marks	Guidance
	c		fits evidence; *idea of* more, evidence / research (since nineteenth century);	1 max	**CREDIT** examples, e.g. DNA revolution / more fossils **ACCEPT** improved technology / molecular evidence **IGNORE** 'the theory has been proved' **IGNORE** Darwin provided more evidence **ACCEPT** changes in religious belief **Examiner's Comments** This question was well answered with most gaining the mark for the idea of more evidence often linked to an example, such as DNA. Some also gained the mark for identifying the influence of religion on 19th century society.
	d	i	specification;	1	**Examiner's Comments** The vast majority of candidates correctly identified speciation as the answer. Variation, adaptation, mutation, and natural selection were also seen.

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Question			Answer/Indicative content	Marks	Guidance
		ii	*idea that* different islands have different, selection pressures / habitats / environments / vacant niches; **ora** *idea of* isolation; **ora**	1 max	**CREDIT** 'the Galapagos have a wider range of habitats' **IGNORE** islands have different habitat(s) from the mainland e.g. the islands are separated from the mainland / no gene flow / geographic barrier / reproductive barrier **ACCEPT** allopatric (speciation) **IGNORE** sympatric **IGNORE** refs to succession or human habitat destruction on the mainland as the question is about evolution **Examiner's Comments** Most candidates were able to get the idea of isolation or more varied selection pressures into their answer. The commonest incorrect answers discussed the influence of humans on the islands.
			Total	**6**	
27			**1** immunity involves / bacteria do not have, lymphocytes / white blood cells / antibodies / memory cells / plasma cells / an immune system; **2** (correct term is) resistant; **3** bacteria are unicellular / only multicellular organisms (can) have an immune response;	3	**Examiner's Comments** This question differentiated well between candidates. The vast majority of candidates knew that 'resistant' was the correct term. A few mentioned resistant, but were not awarded the mark because they went on to state that resistance was a form of partial or temporary immunity. Around half of candidates knew that immunity involved an immune response and were able to give enough detail to get a mark. Very few candidates referenced the fact that, in order to have an immune system, an organism needs to be multicellular.
			Total	**3**	

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Question	Answer/Indicative content	Marks	Guidance
28	**A1** independent assortment / random segregation, of (homologous) chromosomes / bivalents; **A2** in, metaphase **I** / meiosis **I**; **A3** *of* chromatids in, metaphase II / meiosis II; **A4** (so) homologous chromosomes, have different alleles / come from different parents; **A5** produces large number of allele combinations; **C1** crossing over / (formation of) chiasma(ta); **C2** in, prophase **I** / meiosis **I**; **C3** (so) chromatids will have new combination of alleles; **C4** amount of variation depends on distance between crossover points; **M1** mutation; **M2** changes the (DNA) nucleotide/ base, sequence; **M3** DNA checks (during duplication) did not recognise damage; **M4** *idea of* differences in (named) protein(s); **N1** non-disjunction; **N2** homologous chromosomes do not separate (in metaphase I); **N3** one, more / less, chromosome present;	8 max	**A1 ACCEPT** Random assortment / independent segregation **A2 / A3 DO NOT CREDIT** metaphase / meiosis, I **and** II **A2 / A3 ACCEPT** correct anaphase stage linked to segregation **A2** must be in context of independent assortment / random segregation **A4 / A5 DO NOT CREDIT** genes **A4 ACCEPT** pairs of chromosomes / maternal **and** paternal chromosomes, have different alleles / come from different parents **A5 ACCEPT** different combinations of, chromatids / chromosomes, in gametes **CREDIT** figures e.g. for humans 2^{23} possible combinations **C1 DO NOT CREDIT** between sister chromatids **C2 DO NOT CREDIT** prophase / meiosis, I **and** II **C2** must be in context of crossing over **C3 ACCEPT** shuffles / swaps / exchanges, alleles on chromatids **C4** e.g. more variation the further apart the crossovers occur **M2 IGNORE** 'pairs' **M2 CREDIT** deletion, / substitution / addition, of, base / nucleotide **M3 ACCEPT** proof reading did not recognise damage **M4** e.g. change in, amino acid sequence / primary structure **N1 CREDIT** inversion / translocation (chromosome mutation) **N2 CREDIT** description of inversion / translocation **N3 CREDIT** examples of chromosome changes e.g. Trisomy 21

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Question	Answer/Indicative content	Marks	Guidance
	F1 random, mating / fusion of gametes/ fertilisation; **F2** gametes are not genetically identical; **F3** produces large number of (allele) combinations;		**F2 ACCEPT** gametes are genetically different **F3 DO NOT CREDIT** produce large number of gene combinations
	QWC;	1	**Awarded for one change and consequence of that change** **Award if ONE of the following has been awarded** mp **A1 or A2 or A3 <u>and</u>** mp **A4** or **A5** **OR** mp **C1 or C2 <u>and</u>** mp **C3 or C4** **OR** mp **M1 or M2 <u>and</u>** mp **M3 or M4** **OR** mp **N1 or N2 <u>and</u>** mp **N3** **OR** mp **F1 or F2 <u>and</u>** mp **F3** **Examiner's Comments** This question discriminated well across the mark range, with many candidates able to relate genetic variation to the stages of meiosis. Weaker candidates merely listed the events of each stage of meiosis, without linking them to the way in which genetic variation was achieved, gaining no credit. Candidates should be encouraged to read the question again after they have answered it to check they have followed the instructions correctly. The most common responses seen talked about independent assortment of chromosomes in metaphase I and chromatids in metaphase II,crossing over in prophase I, mutation and random fertilisation, all of which gained credit. However, some candidates confused the terms chromosomes and chromatids, for example talking about crossing over between sister chromatids, which lost the marking point. Other common errors were a lack of appropriate detail, for example fertilisation rather than random fertilisation,

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Question			Answer/Indicative content	Marks	Guidance
					daughter cells rather than gametes, which meant that the marking points F1 and F2 could not be awarded. Few candidates related the processes involved in creating genetic variation to the consequences of that process, i.e. the production of new combinations of alleles in the gametes, and so failed to gain the QWC mark.
			Total	**9**	

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Question			Answer/Indicative content	Marks	Guidance
29	a	i	geographic(al);	1	**Mark the first answer**. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **ACCEPT** ecological **IGNORE** physical / barrier **Examiner's Comments** This question was answered well, but sometimes candidates confused their answer with types of speciation. Allopatric was a common mistake, as was geological as opposed to geographical.
		ii	genetic drift;	1	**Mark the first answer**. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **Examiner's Comments** The majority of candidates answered this question correctly. The most common error was to name it as mutation.

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Question			Answer/Indicative content	Marks	Guidance
		iii	*C because* has the greatest change in allele frequency / described; smaller population / fewer individuals; *idea that* more, subject to founder effect / unrepresentative at start; *(more subject to genetic change because)* each random mating more significant **or** each individual forms a greater proportion of gene pool **or** each individual has greater effects on gene pool (than in large population) **or** easier to lose allele from gene pool;	2 max	**If C not identified then no marks awarded** **Look for comparative points with other populations** **ACCEPT** p and q for allele eg 'frequency of allele in C changed by 0.20 whilst it changed by 0.02 in A and 0.14 in B' **ACCEPT** figs as % **ACCEPT** smallest /fewest **Examiner's Comments** A minority of candidates did not identify C correctly and gained no marks. Identifying C because it has the greatest change in allele frequency or the use of figures to demonstrate the same point was the most common correct answer. Some candidates failed to compare the allele frequency change to other populations so didn't gain the mark. Fewer candidates went onto gain a second mark for identifying C as the smallest population, many attempted it but again without making the answer comparative, gained no credit. Other mark points were very rarely awarded as candidates did not talk about individuals or the gene pool.

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>b</td><td>i</td><td>1401;;;</td><td>3</td><td>Correct answer = 3 marks

Award 2 max
if answer not given to the nearest whole number or is incorrect or missing,
then

CREDIT correct working in table columns as follows:
both figures in one column correct = 1 mark. (N.B. Minus sign required for column 1)

ALLOW ecf from any incorrect column to 2 max

<table>
<tr><th>Phenotype of fly</th><th>O - E</th><th>$(O - E)^2$</th><th>$\frac{(O - E)^2}{E}$</th></tr>
<tr><td>red eye, yellow body</td><td>- 354</td><td>125316</td><td>348 (348.100)</td></tr>
<tr><td>pink eye, yellow body</td><td>341</td><td>116281</td><td>323 (323.003)</td></tr>
<tr><td>red eye, ebony body</td><td>369</td><td>136161</td><td>378</td></tr>
<tr><td>pink eye, ebony body</td><td>- 356</td><td>126736</td><td>352</td></tr>
</table>
Examiner's Comments

It was pleasing to see that the vast majority of candidates had a thorough understanding of the chi-squared calculation, gaining full marks. Those who didn't tended to pick up 2 marks for getting the column numbers correct as they had made mistakes in their final calculation.</td></tr>
</table>

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Question			Answer/Indicative content	Marks	Guidance
		ii	*reject hypothesis because* calculated χ^2 value / 1401, is (much) larger than, critical value / 11.35;	1	**ALLOW ecf** for a correct explanation that corresponds to the candidate's incorrect calculation for (i) **CREDIT** *idea that* probability that these results are due to chance is (much) less than 1% / 0.01 **Examiner's Comments** Many candidates gained this mark. Some candidates stated ´accept´ and lost the mark or didn´t give sufficient detail. For instance, several candidates just wrote 'reject hypothesis' without further explanation, and some did not mention critical value or chi squared value in their answers.

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Question			Answer/Indicative content	Marks	Guidance
		iii	(autosomal) linkage **or** genes / alleles, are linked; on same chromosome; linked alleles inherited together; **Ry** and **rY** (on chromosomes in heterozygotes); crossing-over produced (rare) recombinants; tight linkage / two genes close together;	3 max	**DO NOT CREDIT** sex linkage **IGNORE** epistasis **ACCEPT** annotated drawing **ACCEPT** recombinant phenotypes described **ACCEPT** loci close together **Note** '*The alleles R & y and r & Y are inherited together*' = 2 marks (mps 3 & 4) '*The alleles for red eyes and ebony body, and pink eyes and a yellow body, are inherited together*' = 2 marks (mps 3 & 4) **Examiner's Comments** This question was very poorly answered. The majority of candidates gave ´epistasis´ as their answer and some also gave ´sex-linkage´ as an answer, which gained no credit. A significant number discussed environmental pressures as being the cause, even though the question asked for a genetic explanation. Those that correctly identified linkage were mostly able to give good descriptions and gain full marks. A few candidates who did mention linkage did not get mp 3 as they mentioned linked genes being inherited together rather than linked alleles being inherited together.
			Total	**11**	

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Question			Answer/Indicative content	Marks	Guidance
30			*producing nicotine is (selectively) advantageous as* **A1** stops, plant being eaten / loss of leaf area; **A2** so plant, survives / does breed / (still) produces seeds; **A3** *idea that* gene must be advantageous to be selected for **or** gene is linked to another gene that is selected for; *producing nicotine is (selectively) disadvantageous* **D1** decreases, reproductive success / number of seeds; **D2** metabolic resources diverted to nicotine production;	3 max	**mp must be in correct context (ie advantage/ disadvantage) to be awarded** **A1 ACCEPT** deters / kills, grazers / insects **Examiner's Comments** Most candidates were able to make some sensible suggestions, in the correct context, in response to this question. Marking point D1 was most commonly given, but only a minority of candidates were able to explain that the reduced seed production was due to energy or resources being used to make nicotine instead (MP D2). Several candidates were also able to identify insect deterrence as a selective advantage (MP A1), and a number of those then went on to gain marking point A2 (usually for increased survival). In general, candidates need to be reminded to look for both sides of the argument and identify selective advantages and disadvantages. A few candidates gave confused answers falsely linking the addictive properties of nicotine in humans to insects that might continue eating the plant in order to get more nicotine.
			Total	**3**	

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Question			Answer/Indicative content	Marks	Guidance
31		i	*discontinuous* gender / male and female / eye colour; *continuous* size / length / mass;	2	**Mark the first answer on each prompt line.** If an additional answer is given that is incorrect or contradicts the correct answer, then = **0 marks** **Note:** Suggestions must relate to **visible** characteristics of the **frogs**, **ACCEPT** sex **IGNORE** skin colour (as stated in Q), **CREDIT** example of a ***measurable*** characteristic (e.g. leg length, surface area, height, weight) **Examiner's Comments** The majority of candidates could correctly identify a phenotypic characteristic which showed a continuous pattern of variation, but, surprisingly, many could not give an acceptable example of discontinuous variation. Some failed to use the information given, stating colour as an example, or blood group, neither of which were allowed.

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Question			Answer/Indicative content	Marks	Guidance
		ii	*idea of* 1 no / little, environmental effect for, (named example of) discontinuous variation / example given for discontinuous variation in **(i)** as ecf; 2 some / large, environmental effect for, (named example of) continuous variation / example given for continuous variation in **(i)** as ecf; 3 gender may be affected by, temperature / atrazine exposure;	2	**IGNORE** examples of environmental factors **ACCEPT** discontinuous variation is ***only,*** genetic / due to alleles present **Note:** A comparative statement (e.g. 'environment has a greater effect on continuous variation') = **2 marks** (mps 1 & 2) e.g. 'no environment effect for discontinuous variation but it does affect continuous variation' = **2 marks** (mps1 &2) **Examiner's Comments** Most candidates performed well. Others described factors that affected the type of variation and didn't write 'environmental' or address the question 'Discuss the extent to which' and so lost marks as a result.
		iii	1 *idea that* offspring visibly different from, A / egg donor; 2 to show that the offspring produced were clones; 3 to show / identify, (genetic) parents (of clone) / B and C;	2 max	**ACCEPT** brown frog for A **2** 'to show that cloning is successful' is **not** enough **Note:** 'To show that the offspring were clones as they are not the same as A.' = **2 marks** (mps 1 & 2) **Examiner's Comments** This was a challenging question, with many candidates suggesting that albino frogs were being used as they were endangered or possessed a desirable characteristic, rather than the idea that the offspring would be visibly different to the egg donor, but identical to the genetic parents or other clones.

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Question			Answer/Indicative content	Marks	Guidance
			Total	**6**	

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Question			Answer/Indicative content	Marks	Guidance
32	a		(belong to the) same genus;	1	**Examiner's Comments** It was surprising how many candidates did not know the answer genus. Common suggestions were phylum, taxonomic group, same species or general comments about them just having common ancestors, which failed to gain credit.
	b	i	**1** not much / little / some, competition / niche overlap; *reasons for little competition* **2** use / feed on, different sized flowers / different depth of flowers; **3** vary in proportions of pollen **and** nectar they collect; **4** fly / live / active / feed / visit flowers, at different times; *reason for competition* **5** *idea that* fly / live / active / feed / visit flowers, overlaps there must be competition;	4 max	**This mark is for a stand alone statement** **DO NOT CREDIT** no competition **IGNORE** competition unqualified / inter / intra **2 CREDIT** correct comparative description or use of data e.g. *B. pratorum feed* on, bigger / longer / deeper, flowers **or** *B. pratorum* 7.4(mm) **and** *B. terrestris* 6.3(mm) **3 CREDIT** correct description e.g. *B. pratorum* mostly pollen and nectar **and** *B. terrestris* mostly nectar only **or** comparison of 2 species using table data **IGNORE** 'different amounts' of pollen and nectar **4 CREDIT** correct description of difference e.g. *B. pratorum* peak in June **and** *B. terrestris* in July **or** *B. pratorum* appear in earlier in the year **or** comparison of 2 species using graph data **5 CREDIT** correct description from data e.g. both compete for food between May and September / both collect pollen only from same % flowers 6 e.g. use / feed on, different species of

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Question			Answer/Indicative content	Marks	Guidance
			6 AVP;		flowers **Examiner's Comments** Most candidates got the idea that there was some degree of competition, and successfully gained 1 or 2 marks, but generally answers were poorly constructed with many candidates using the space available to explain just one or two marking points. For example, many candidates achieved marking point 5, referring to numerous examples of competition in their answer, but only able to achieve one mark. Candidates were good at using data from the graph and table, but often in a vague way - eg. 'peak in the summer months' - and without relating it to the question. Common errors were giving the wrong time scale from x axis, not mentioning both nectar and pollen for mp3 and saying that bees competed as they visited flowers of similar or same depths, or that one species outcompeted the other species of bee.

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Question			Answer/Indicative content	Marks	Guidance
		ii	**1** *idea of* isolation / isolating mechanism / barrier; **2** seasonal (difference) / temporal (difference) / males and queens (in different populations) produced in different months / breeding (in different populations) in different months; **3** behavioural (difference) / visit different (types of) flowers / feed at different times / feed on different food types; **4** different flower locations / different (micro)habitats; **5** *idea that* gene flow restricted / no gene flow (between populations); **6** different adaptations / specialisation / niche partitioning;	3 max	**2 CREDIT** example of seasonal / temporal (e.g. *B. pratorum* has its peak number of workers in June and *B. terrestris* in July) **3 CREDIT** 'different mating rituals' **5 must refer to gene / allele** **6 IGNORE** speciation (as implied in Q) - can be mistaken for specialisation **Examiner's Comments** The majority of candidates scored well on this question. Most recognised the need for isolation / barriers and mentioned seasonal and / or behavioural differences. However, few mentioned the idea of restricted gene flow and specialisation in the two separate populations leading to the evolution of the new species.

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<table>
<tr><th colspan="3">Question</th><th>Answer/Indicative content</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>c</td><td>i</td><td><table><tr><th>Observation</th><th>Type of behaviour</th></tr><tr><td>The time taken for a worker bee to collect food from a flower decreases with practice.</td><td>learned (behaviour) / learning / operant conditioning / trial and error ;</td></tr><tr><td>All bumble bees start at the bottom of a vertical spike of flowers and work upwards.</td><td>innate / instinctive ;</td></tr></table></td><td>2</td><td>Mark the first answer in each box. If an additional answer is given that is incorrect or contradicts the correct answer, then = 0 marks

ACCEPT taxis / example of taxis eg chemotaxis
IGNORE inherited / genetically determined
DO NOT CREDIT kinesis

Examiner's Comments

This was generally a well-answered question with many candidates gaining 2 marks. Most common answers were learned and innate behaviour. Common errors included giving latent or insight learning for mp1 or even reference to conditioning on its own. There were problems with some candidates offering multiple answers one of which was incorrect, therefore negating their marks.</td></tr>
<tr><td></td><td></td><td>ii</td><td>Idea that better / more efficient, at, finding / getting, food;

AVP;</td><td>1 max</td><td>ACCEPT more food can be collected less, time / energy, spent looking for food easier to find food
e.g. ref to reduces competition from other colonies

Examiner's Comments

A well-answered question with the majority of candidates getting the mark. Many of those who did not achieve the mark were writing vague references to the bees increasing their chance of survival.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>11</td><td></td></tr>
<tr><td>33</td><td></td><td></td><td>B ☒</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
<tr><td>34</td><td></td><td></td><td>D ☒</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
</table>

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Question			Answer/Indicative content	Marks	Guidance
35	a	i	number of seeds per pot ☐ size of pot ☐ type of soil / compost used ☐ mass of soil / compost used ☐ temperature ☐ light intensity ☐ oxygen / carbon dioxide concentration ☐ AVP ☐	Max 2	e.g. depth of planting
		ii	% moisture on horizontal axis and number seedlings germinated on vertical axis☐ both axes clearly labelled with unit for moisture☐ plots for separate species clearly distinguished☐ points plotted accurately☐	4	**ACCEPT** either line graph with two lines or bar chart with two bars at each moisture level
	b	i	correct data entered into all cells in table ☐ $\Sigma d^2 = 2$ ☐	1	<table><tr><td>60</td><td>4</td><td>42</td><td>5</td></tr><tr><td>80</td><td>5</td><td>33</td><td>4</td></tr><tr><td></td><td></td><td></td><td></td></tr></table>
		ii	0.9 ☐☐	2	Two marks for correct answer If answer incorrect allow one mark for work showing formula completed correctly $r_s = 1 - \frac{6 \times 2}{5(25 - 1)}$
		iii	the correlation (between moisture and germination) is not significant (at the p = 0.05 / 95% confidence level)☐	1	
			Total	**11**	

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Question			Answer/Indicative content	Marks	Guidance
36	a	i	action potential / nervous impulse, in sensory neurone ☐ synapse / described ☐ relay / intermediate, neurone ☐ (nervous impulse in) motor neurone, passes to / AW, effector / muscle ☐	3 max	
		ii	*idea of* maintains balance / efficiency of movement ☐	1	
		iii	kinetic / movement, energy converted ☐ to, electrical energy / action potential ☐ *idea of* movement of statolith moves sensory hairs ☐ membrane of sensory hairs depolarises ☐	3 max	
	b		*Support is weak because* *idea that* clasification based on phylogeny ☐ statocysts could, have evolved on more than one occasion / be an example of convergent evolution ☐	2	
			Total	**9**	

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