

Questions

Q1.

Wasps are insects that live in groups.

One species of wasp (*Vespula germanica*) has been shown to knock its body repeatedly against a hard surface. This signals the presence and quality of food to other wasps.

When threatened by another animal, it may use its stinger to inject a venom to protect itself.



bugguide.net

Complete the table by giving the name of the type of adaptation.

(2)

Description of adaptation	Type of adaptation shown by the wasp
knocking its body to signal food	
the stinger	

(Total for question = 2 marks)

Q2.

Answer the questions with a cross in the boxes you think are correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

Moving a limb involves the interaction of muscles, tendons and ligaments.

Tendons and ligaments are important structures in elbow and knee joints.

(i) Which of the following identifies the structures that join bones to bones in an elbow joint? (1)

- A ligaments only
 B ligaments and tendons
 C tendons only
 D neither ligaments nor tendons

(ii) One type of joint injury is a torn ligament. This may be treated by adding a piece of tendon to the ligament. This is because after a period of time, the tendon tissue changes and responds in the same way as a ligament.

Which of the rows in the table correctly describe the changes in this piece of tendon? (1)

Row	Piece of tendon shows a change in its	The change is
1	genotype	an anatomical adaptation
2	genotype	a physiological adaptation
3	phenotype	an anatomical adaptation
4	phenotype	a physiological adaptation

- A row 1 only
 B row 3 only
 C rows 1 and 2
 D rows 3 and 4

*(iii) The photograph shows athletes competing in the modern triathlon.



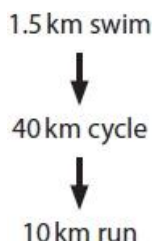
© Gonzalo Arroyo Moreno/Stringer

The modern triathlon involves three sports: swimming, cycling and running.

An investigation was carried out to compare the level of demand on the body of these three sports during a triathlon.

The investigation involved 12 athletes who were all males of the same age.

Each athlete carried out the triathlon as shown in the flow diagram. There was no rest period between each sport.



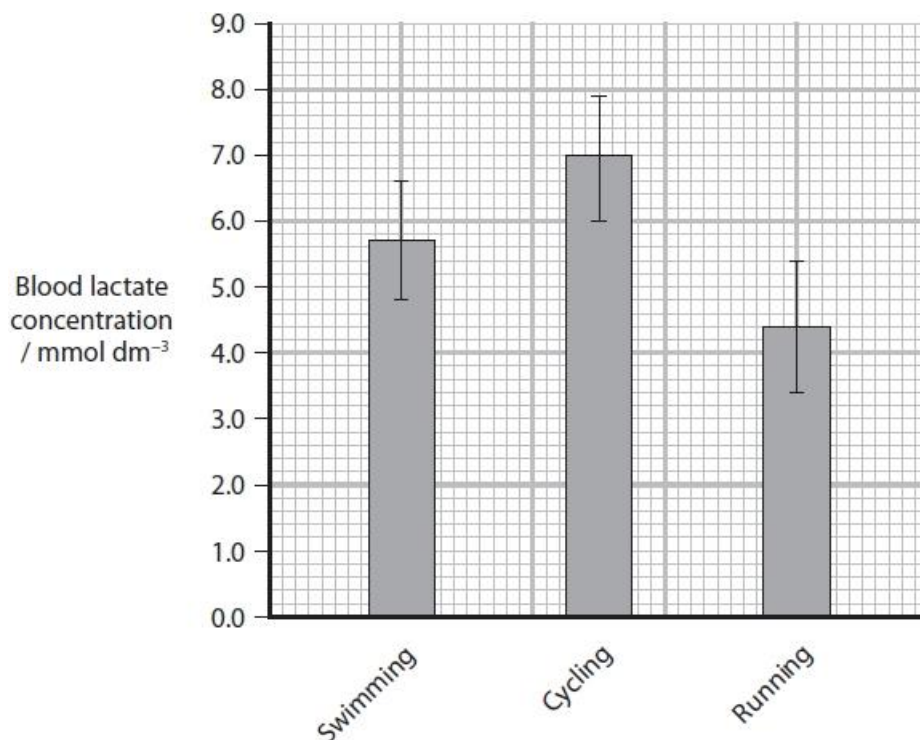
The heart rate for each athlete was measured as they completed each sport.

The mean heart rate for each sport was then calculated and is shown in the table.

Sport	Mean heart rate / bpm
Swimming	163
Cycling	165
Running	159

The blood lactate level for each athlete was also measured as they completed each sport. Means for lactate level after each sport were calculated.

The results are shown in the graph.



It was concluded that cycling was the most demanding of the three triathlon sports. This was followed by swimming and then running.

Evaluate the validity of this conclusion.

(6)

(Total for question = 8 marks)

Q3.

The genomes of some species of cichlid fish have been sequenced and analysed.

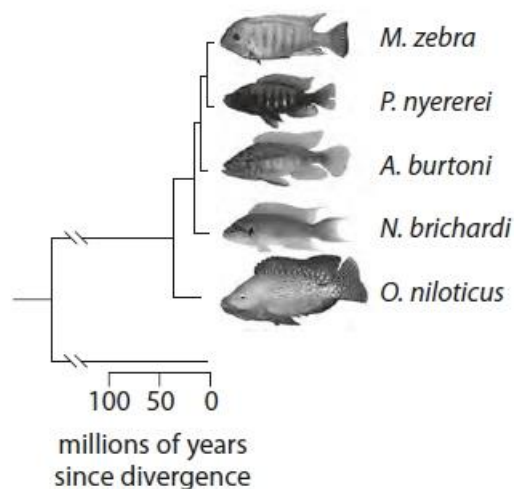
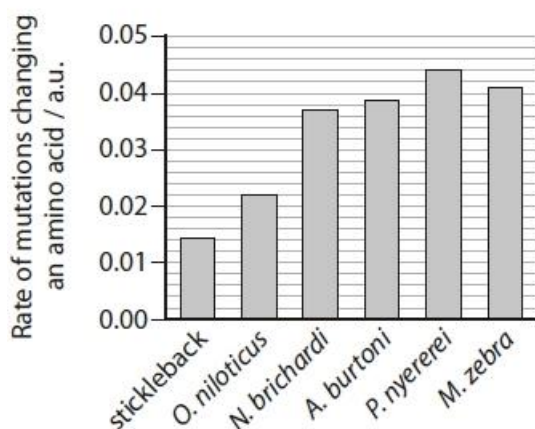
The data collected included:

- the rate at which genes have been duplicated to produce additional copies of genes on a chromosome
- the frequency of mutations in transcription factor binding sites
- the rate of mutations that result in a change of an amino acid in a protein.

This information was used to produce a phylogenetic tree.

A comparison was made with a stickleback, which is a slowly evolving fish.

Speed of evolution	Fish	Rate of gene duplication / a.u.	Number of mutations in transcription factor binding sites (compared to <i>O. niloticus</i>)
Rapidly evolving cichlid fish	<i>O. niloticus</i>	45	0
	<i>N. brichardi</i>	45	214
	<i>A. burtoni</i>	55	140
	<i>P. nyererei</i>	45	129
	<i>M. zebra</i>	60	142
Slowly evolving fish	stickleback	10	0



Q4.

Conservation programmes are used to save endangered species.

The Scottish wildcat, shown in the photograph, is a subspecies of the European wildcat, *Felis silvestris silvestris*.



The Cairngorms Wildcat Project estimates that there are 150 breeding pairs left, but the Scottish Wildcat Association believes that only 35 cats remain.

A conservation group proposed that a captive breeding programme, and the relocation of Scottish wildcats, would be necessary to prevent extinction.

(i) State why the Scottish wildcat has been described as **endemic**.

(1)

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(ii) The Scottish wildcat can interbreed successfully with domestic cats.

Explain the effect this could have on the genetic diversity of the Scottish wildcat.

(2)

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(Total for question = 3 marks)

Q5.

All known organisms can be placed into one of the three domains of life.

The table shows some information about the three different domains.

Feature	Archaea	Bacteria	Eukaryota
DNA is circular	Yes	Yes	No
DNA is single-stranded	No	No
Growth inhibited by the antibiotic streptomycin	No	Yes	No
Name of the link between fatty acids and glycerol in lipids	Ether	Ester	Ester
Presence of cell wall	Some	Yes
Methionine required for starting protein synthesis	Yes	No	Yes
Transcription factors required for transcription	Yes	No	Yes

Complete the table to show the features in Bacteria and in Eukaryota.

(2)

(Total for question = 2 marks)

Q6.

Scientists have studied behavioural, anatomical and genetic variation in elephants.

The table shows some information about two populations of African elephants.

Population	Location	Feeding behaviour	Anatomical differences
Forest elephant	tropical forest of central and West Africa	feeds on leaves and fruits of high-growing plants such as shrubs and trees	<ul style="list-style-type: none"> • lower jaw longer and narrower • tusks straighter and downward facing • overall a much smaller size
Savannah elephant	African savannah	feeds on grass and leaves of low-growing shrubs	<ul style="list-style-type: none"> • lower jaw shorter and wider • tusks more curved and upward facing • overall a larger size

The photographs show elephants from the two populations.



Forest elephant



Savannah elephant

DNA samples were collected from these two populations of elephants.

One of the genes showing variation was the GBA gene. The table shows the frequency of the alleles of the GBA gene in the two populations.

GBA allele	Frequency of allele in the elephant population	
	Savannah elephant	Forest elephant
J	0.05	0.43
K	0.00	0.57
L	0.95	0.00

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

(1)

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(ii) Use the Hardy-Weinberg equation to show that more than 50% of the forest elephant population are homozygous for the GBA gene.

(3)

Answer

(Total for question = 4 marks)

Q7.

Some fish live in very cold parts of the sea where ice can form.

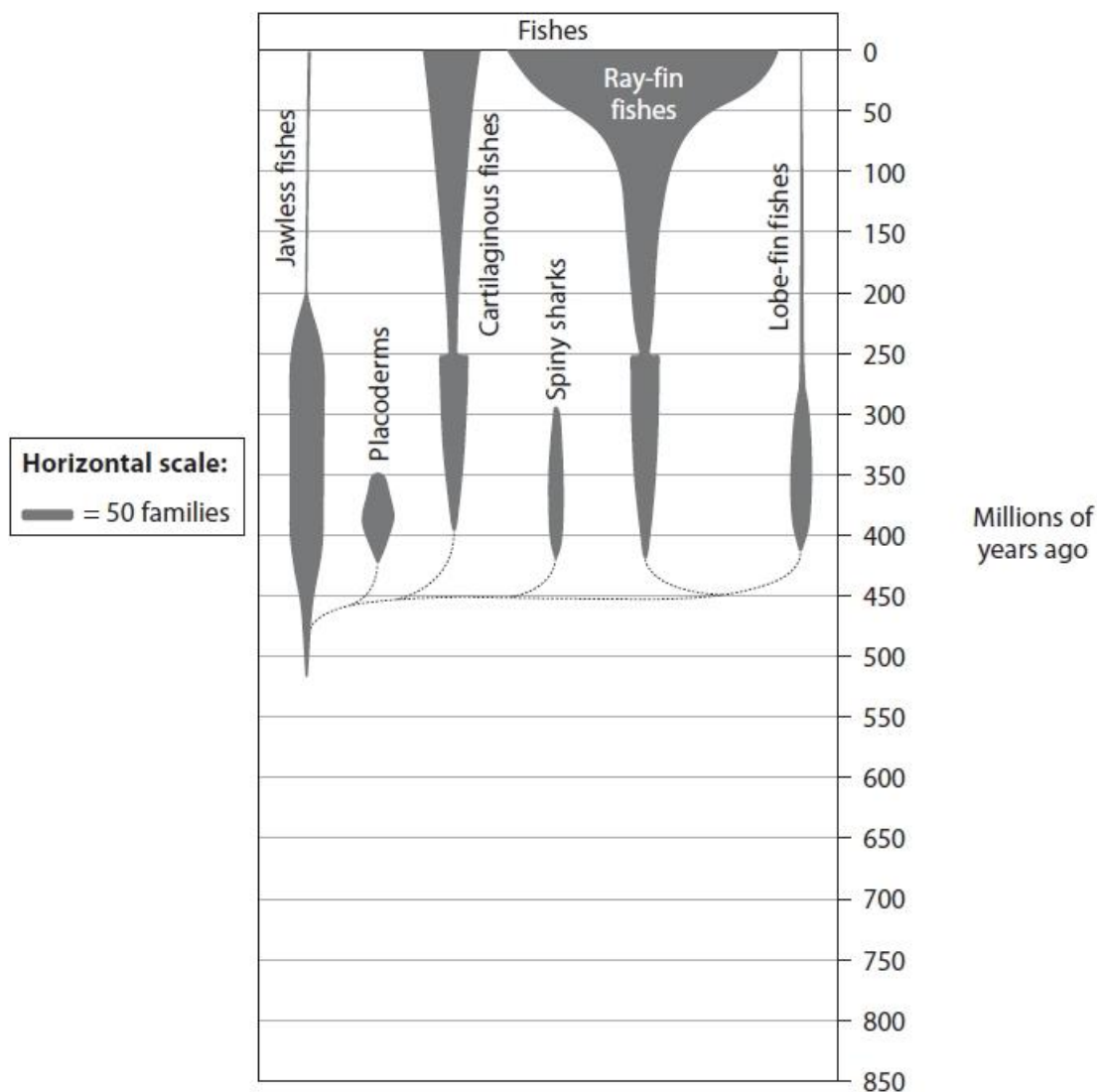
Many of these fish produce anti-freeze proteins, which help to stop ice forming inside the fish.

Sea ice forms only during ice ages.

The table shows Earth's ice ages over the last 1000 million years.

Ice age	Time / millions of years ago
Quaternary	0 to 2.6
Karoo	260 to 360
Andean-Saharan	420 to 460
Cryogenian	630 to 850

The diagram shows how the number of families of fishes has changed over time.



(i) At which time does the diagram show a major loss of biodiversity?

(1)

- A 65 million years ago
- B 252 million years ago
- C 359 million years ago
- D 419 million years ago

(ii) Many different types of anti-freeze protein are produced by ray-fin fishes.

Analyse the data to explain when these ray-fin fish are likely to have evolved the ability to produce anti-freeze proteins.

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(Total for question = 4 marks)

Q8.

Biodiversity can be reduced by management of habitats.

A study of plant species, other than grasses, found in two lawns was completed.

Lawn A was cut every 14 days. Lawn B was cut every 7 days.

The table shows the number of plants of each species identified.

Plant species	Number of plants	
	Lawn A	Lawn B
Daisy	18	5
Bee orchid	1	0
Dandelion	12	0
Clover	4	0
Bird's-foot trefoil	6	0

Biodiversity can be compared in different habitats using a formula to calculate an index of diversity (D).

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

n = total number of organisms of a particular species

N = total number of organisms of all species

(i) Calculate the index of diversity for lawn A.

(3)

Answer

(ii) Herbicides are sprayed on lawns to kill unwanted plants.

Explain how the calculated value would change if a herbicide was used on this lawn.

(2)

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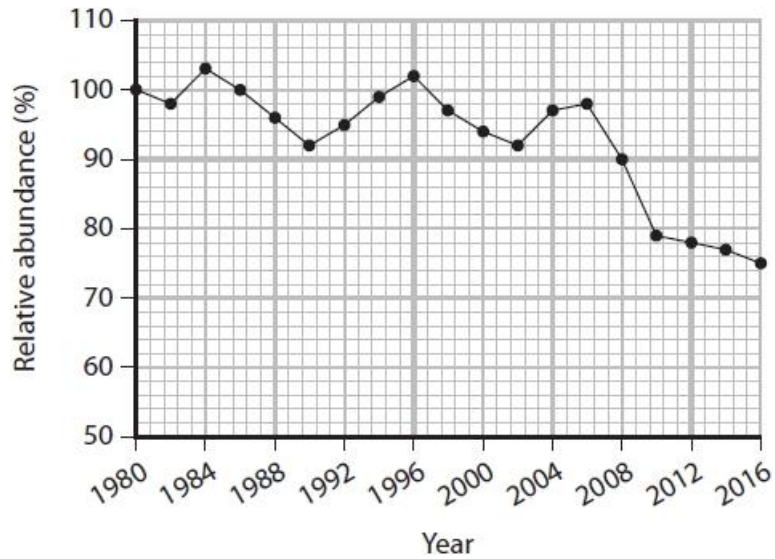
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(Total for question = 5 marks)

Q9.

* The graph shows the changes in the relative abundance of pollinating wild bee species in the UK. The original sample in 1980 represents a value of 100%.



Explain how the changes in the relative abundance of bee species in the UK may result in the development of a new species of bee orchid.

(6)

(Total for question = 6 marks)

Q10.

Muscular dystrophy is a group of disorders that gradually cause muscles to weaken.

One type of muscular dystrophy, caused by a recessive allele, affects 10 people in 100 000 of the population.

Calculate the number of carriers in a population of 17.02 million.

Use the Hardy-Weinberg equation, $p^2 + 2pq + q^2 = 1$

(3)

Answer

(Total for question = 3 marks)

Q11.

Cystic fibrosis is a genetically inherited condition.

A couple who are both carriers for the condition have a 25% chance of having a baby with cystic fibrosis. In the UK, 1 in 2500 babies born have cystic fibrosis.

Use the Hardy-Weinberg equation to calculate the probability of babies born in the UK being carriers for cystic fibrosis.

(3)

Answer

(Total for question = 3 marks)

Q12.

All known organisms can be placed into one of the three domains of life.

The table shows some information about the three different domains.

Feature	Archaea	Bacteria	Eukaryota
DNA is circular	Yes	Yes	No
DNA is single-stranded	No	No
Growth inhibited by the antibiotic streptomycin	No	Yes	No
Name of the link between fatty acids and glycerol in lipids	Ether	Ester	Ester
Presence of cell wall	Some	Yes
Methionine required for starting protein synthesis	Yes	No	Yes
Transcription factors required for transcription	Yes	No	Yes

Explain how the information in the table can be used to show that the Archaea are more closely related to the Eukaryota than to the Bacteria.

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(Total for question = 3 marks)

Q13.

Tropical rainforests play a role in maintaining biodiversity and in storing carbon.

Information on biodiversity has been collected from various rainforest habitats in Madagascar.

(i) Describe what needs to be measured in order to compare the biodiversity of two rainforests.

(2)

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(ii) The biodiversity of the land area of Earth has been estimated.

The table shows information on the number of species of plants and vertebrate animals in the rainforests of Madagascar and for the land area of Earth.

Region	Plants		Vertebrate animals		Land area / km ²
	Number of known species	Number of known endemic species	Number of known species	Number of known endemic species	
Madagascar	12 000	9704	987	771	59 300
Land area of the Earth	300 000	300 000	27 300	27 300	149 000 000

Analyse the data to determine the importance of the rainforests of Madagascar in maintaining biodiversity on Earth.

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(Total for question = 5 marks)

Q14.

Sloths are mammals found in Central and South America.

Sloths are slow moving and use their hooked claws to hold onto branches. They sleep for over 15 hours a day. During this time, their slow metabolism processes their diet of low nutrition vegetation.



Sloths have behavioural, physiological and anatomical adaptations to their environment.

Complete the table using the information provided.

(3)

Type of adaptation	Example
Behavioural	
Physiological	
Anatomical	

(Total for question = 3 marks)

Q15.

Sloths are mammals found in Central and South America.

The map shows the distribution of two species of sloth.

There are currently two major populations of *C. hoffmanni* in South America.

B. pygmaeus is restricted to an island off the coast of Central America.

Each population occupies different habitats.



Discuss why the number of sloth species may change in the future.

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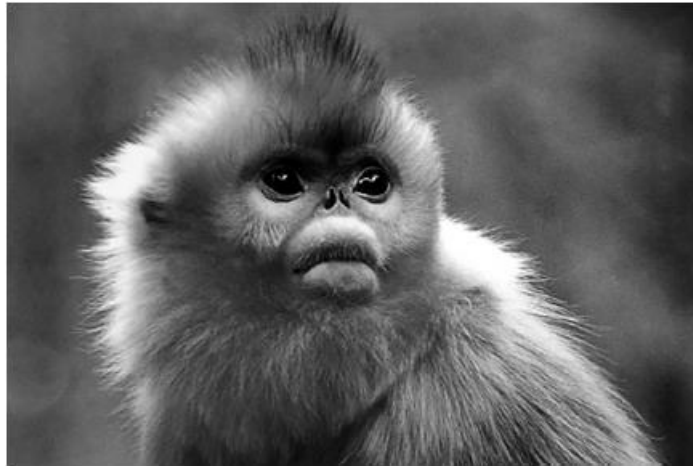
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(Total for question = 6 marks)

Q17.

The golden snub-nosed monkey (*Rhinopithecus roxellana*) is endemic to high mountainous regions of China.

This endangered species of monkey feeds on seeds.



State what is meant by the term endemic.

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(Total for question = 1 mark)

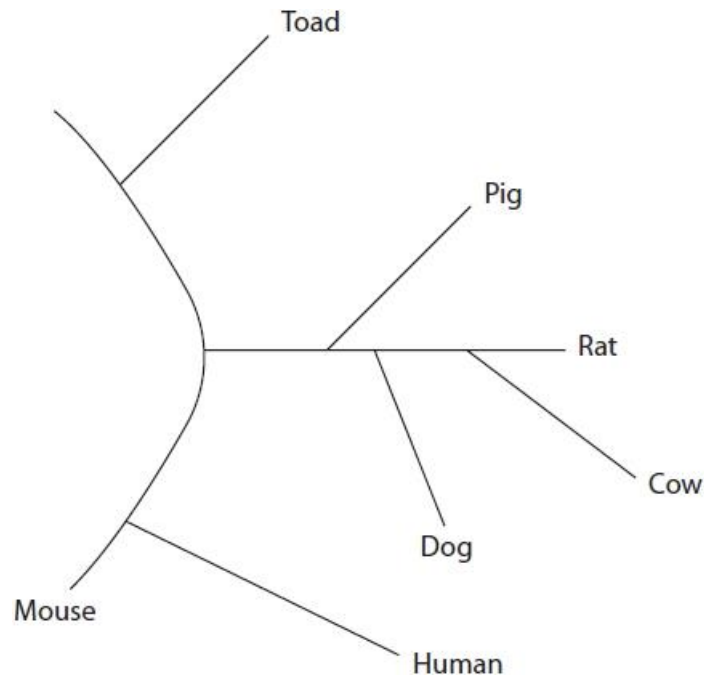
Q18.

Trypsin is an enzyme found in many groups of living organisms.

Trypsin specifically acts on a polypeptide to form amino acids.

The primary structures of trypsin molecules from different species have been used to produce a phylogenetic tree for trypsin.

Each branch of the following phylogenetic diagram represents trypsin from a different species.



Explain how the primary structure of trypsin molecules can be used to produce a phylogenetic tree.

(3)

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(Total for question = 3 marks)

Q19.

Explain how these two species of snake could have arisen from a common ancestor.

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(Total for question = 4 marks)

Q20.

Sloths are mammals found in Central and South America.

Three species of sloth are described in the table.

Species	Common name	Status
<i>Bradypus pygmaeus</i>	pygmy three-toed sloth	critically endangered
<i>Choloepus didactylus</i>	Linné's two-toed sloth	least concern
<i>Choloepus hoffmanni</i>	Hoffmann's two-toed sloth	least concern

It is believed that *C. hoffmanni* and *C. didactylus* shared a common ancestor before becoming isolated on either side of the Andes mountain range.

(i) Explain why they are now classed as different species.

(2)

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(ii) Which of the following describes the term **niche** with reference to *C. hoffmanni*?

(1)

- A the area where *C. hoffmanni* is found
- B the preferred diet of *C. hoffmanni*
- C the risk of *C. hoffmanni* becoming extinct
- D the role of *C. hoffmanni* in its environment

(Total for question = 3 marks)

Q21.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

Red squirrels, *Sciurus vulgaris*, are native to the UK. The grey squirrel, *Sciurus carolinensis*, has been introduced to the UK.



Sciurus vulgaris



Sciurus carolinensis

The two squirrels are classified as different species because they

- A are geographically isolated
- B cannot produce fertile offspring
- C have different coloured fur
- D occupy a different niche

(1)

(Total for question = 1 mark)

Q22.

The population of red squirrels on Brownsea Island is one of several protected populations in the UK.

(i) These red squirrels are not classed as endemic to Brownsea Island because they

(1)

- A are also found in other locations
- B are not at risk of extinction
- C are not in competition with grey squirrels
- D have a large population size

(ii) The red squirrels on Brownsea Island are geographically isolated from other red squirrel populations on the UK mainland.

Over time, the Brownsea Island population of squirrels might develop into a new species. Name the process that could lead to the Brownsea Island population of squirrels becoming a new species.

(1)

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(Total for question = 2 marks)

Q23.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

There are currently three species of badger in the genus *Meles*: the Eurasian badger (*Meles meles*), the Asian badger (*Meles leucurus*) and the Japanese badger (*Meles anakuma*).



© Pearson Asset Library

The South Asian badger is currently classed as *Meles meles*.

The pairing that would be expected to be able to mate and produce fertile offspring is

- A Asian badger and South Asian badger
- B Eurasian badger and Asian badger
- C Eurasian badger and South Asian badger
- D Japanese badger and South Asian badger

(1)

(Total for question = 1 mark)

Q24.

During the civil war in Mozambique, from 1977 to 1992, 90% of the African elephants were killed for the ivory in their tusks.

Since 1992, the elephant population in Mozambique has increased.

The photograph shows a group of elephants in Mozambique.



© ALEXANDER JOE/Staff/Getty Images

A study of an elephant population in Mozambique was carried out in 2017.

The elephants studied were all born before 1992.

The table shows the number of elephants with and without tusks.

Elephants	Number of elephants
with tusks	98
without tusks	102

The presence of tusks is controlled by a single gene. The allele for tusks is known to be dominant.

The frequency of alleles in a population can be determined using the Hardy-Weinberg equation.

Calculate the frequency of the dominant and recessive alleles in this population.
Give your answer to 2 decimal places.

(3)

Frequency of the dominant allele

Frequency of the recessive allele

(Total for question = 3 marks)

Q25.

The arctic ground squirrel (*Spermophilus parryii*) lives in Alaska. It has small ears, a cylindrical body and a shorter tail than other species of ground squirrel.

The arctic ground squirrel can survive cold winters by hibernating for up to eight months per year. When hibernating, arctic ground squirrels use stored fat supplies as an energy source.



www.sciencephoto.com

Which combination of adaptations shown by the arctic ground squirrel have been described?

(1)

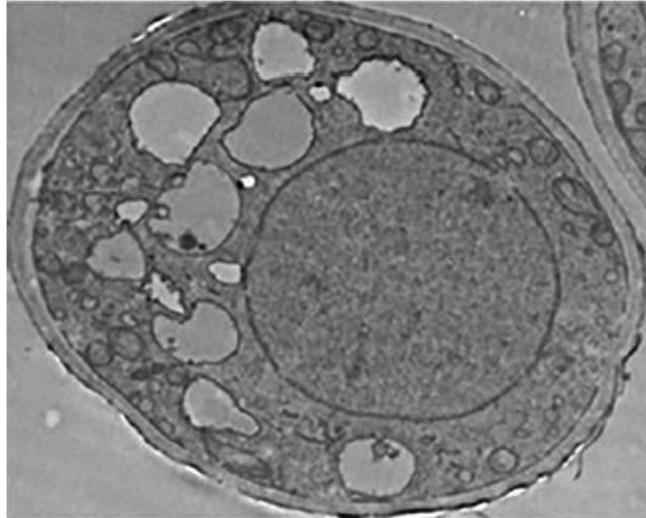
- A anatomical and behavioural only
- B anatomical and physiological only
- C anatomical, behavioural and physiological
- D behavioural and physiological only

(Total for question = 1 mark)

Q26.

Hymenoscyphus fraxineus (*H. fraxineus*) is the fungus that causes ash dieback. This disease usually kills all the ash trees that it infects.

The electron micrograph shows a section through a fungal cell.



Magnification $\times 1000$

To which group do fungi belong?

(1)

- A Archaea
- B Eukaryota
- C Prokaryota
- D Viruses

(Total for question = 1 mark)

Q27.

The red squirrel population on Brownsea Island has been affected by a disease caused by a prokaryotic organism.

(i) Woese classified organisms into domains.

Which of the following contain prokaryotic organisms?

(1)

- A** Archaea, Bacteria and Eukaryota
- B** only Archaea
- C** only Archaea and Bacteria
- D** only Bacteria

(ii) Scientists took blood samples from infected red squirrels and analysed them using an electron microscope.

Describe the features that could be used to identify the prokaryotic cells in the blood sample.

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(Total for question = 5 marks)

Q28.

During the civil war in Mozambique, from 1977 to 1992, 90% of the African elephants were killed for the ivory in their tusks.

Since 1992, the elephant population in Mozambique has increased.

The photograph shows a group of elephants in Mozambique.



© ALEXANDER JOE/Staff/Getty Images

A study of an elephant population in Mozambique was carried out in 2017.

The elephants studied were all born before 1992.

The table shows the number of elephants with and without tusks.

Elephants	Number of elephants
with tusks	98
without tusks	102

In most African elephant populations, 2% to 4% of elephants do not grow tusks.

(i) Explain why the percentage of elephants without tusks in Mozambique will probably increase in the future.

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(ii) Describe how the Hardy-Weinberg equation can be used to provide evidence for changes in the elephant population in Mozambique.

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(Total for question = 5 marks)

Q29.

There are two main types of woodland in the UK. One consists of broadleaved deciduous trees, the other contains coniferous trees that have needle-like leaves.

The table shows some of the species of plant growing underneath the trees in a deciduous woodland.

Species	Number of individuals of each species (n)	$n(n - 1)$
Woodrush	2	
Holly	8	
Bramble	1	
Yorkshire fog	9	
Sedge	3	

(i) Complete the table to show $n(n - 1)$ for each species of plant.

(1)

(ii) Calculate the diversity index (D) using the data in the table.

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

(2)

Answer

(Total for question = 3 marks)

Q30.

There are currently three species of badger in the genus *Meles*: the Eurasian badger (*Meles meles*), the Asian badger (*Meles leucurus*) and the Japanese badger (*Meles anakuma*).

The Bosphorus Strait is a channel of water that separates populations of badgers.

Badgers found to the west of the Bosphorus Strait are *M. meles*. The badgers found to the east of the Bosphorus Strait are thought to be a new species.

(i) Explain how molecular phylogeny can be used to show that these two populations are reproductively isolated.

(3)

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(ii) Describe how mutations in badgers to the east of the Bosphorus Strait may lead to this population becoming a separate species.

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(Total for question = 7 marks)

Q31.

Plasmodium falciparum is a single-celled eukaryotic organism. *P. falciparum* causes the disease malaria when it invades red blood cells.

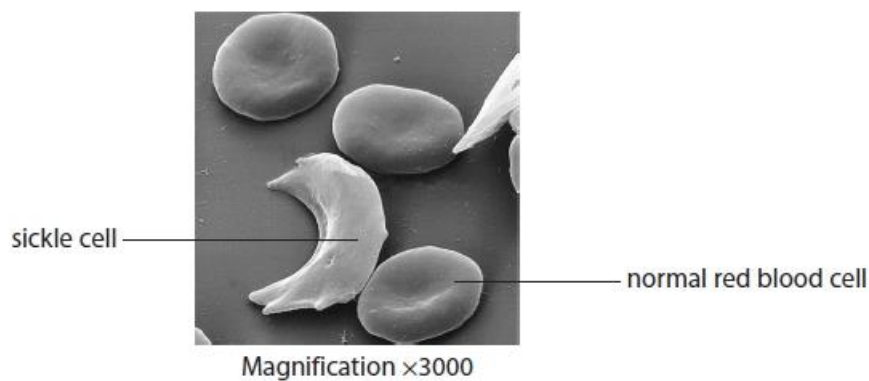
If untreated, malaria can result in a shorter than normal life span.

The high mortality rate of people with malaria has been claimed to be one of the greatest selection pressures on the human genome in recent history.

Sickle cell anaemia is a genetic condition.

People who are homozygous for the sickle cell allele have red blood cells that become deformed in shape when they are deoxygenated.

The electron micrograph shows these deformed sickle cells alongside normal red blood cells.



(i) The image of the normal red blood cell labelled in the electron micrograph has a diameter of 2 μm .

Which of the following is the actual diameter of this red blood cell?

- A 0.67 μm
- B 6.7 μm
- C 67 μm
- D 670 μm

(1)

(ii) People with a heterozygous genotype for this condition do not develop severe sickle cell anaemia.

The Yoruba are a group of people who live in West Africa.

In a population of 600 Yoruba individuals, 24 were found to have severe sickle cell anaemia.

Calculate the number of heterozygous individuals in this population.

Use the Hardy Weinberg equation, $p^2 + 2pq + q^2 = 1$.

(3)

Answer

Q32.

Scientists measure biodiversity using both species richness and the heterozygosity index.

State what is meant by the following terms:

(2)

species richness

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heterozygosity index

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(Total for question = 2 marks)

Q33.

A study of the genetics of grass snakes has led to the identification of a new species of grass snake in the UK.

The barred grass snake was thought to be a variation of the common grass snake, *Natrix natrix*.

However, the barred grass snake, *Natrix helvetica*, has been found to be a different species.

Both types of grass snake are normally found in lowland regions in the south of England. The snakes can be more than a metre long, are found near water and eat mainly amphibians such as frogs and newts.

The common grass snake is olive green with a bright yellow collar.

The barred grass snake, shown in the photograph, is grey with black markings.



State what is meant by the term species.

(1)

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(Total for question = 1 mark)

Q34.

There are many reasons why humans may lose muscle mass.

Two known causes are hip replacement surgery and some genetically inherited conditions.

Muscular dystrophy (MD) is a range of genetically inherited conditions in which a loss of muscle mass can occur.

Limb-girdle muscular dystrophy (LGMD2A) is a rare type of MD. Only six people per million have this recessive condition.

In 2018 there were 66.5 million people in the UK.

(i) Calculate the number of people in the UK who are carriers of LGMD2A using the Hardy-Weinberg equation.

(3)

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

Answer

(ii) In the human population, the frequency of the allele for LGMD2A may change from one generation to the next.

Explain why the frequency of this allele may change from one generation to the next.

(3)

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(Total for question = 6 marks)

Q35.

Explain how the Hardy-Weinberg equation can be used to show that natural selection is occurring in a population.

(2)

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(Total for question = 2 marks)**Q36.**

Some fish live in very cold parts of the sea where ice can form.

Many of these fish produce anti-freeze proteins, which help to stop ice forming inside the fish.

The production of anti-freeze proteins is an example of

(1)

- A** anatomical adaptation
- B** change in allele frequency
- C** physiological adaptation
- D** reproductive isolation

(Total for question = 1 mark)

Q37.

The saiga antelope is found in the grasslands of Eurasia. In the 1970s its population was 1 250 000. The population has decreased due to loss of habitat and a disease outbreak in 2015.

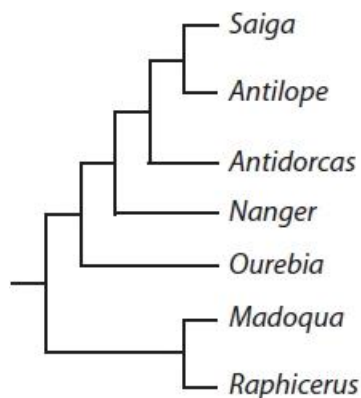
Population estimates suggest as few as 50 000 individuals remain.

Conservation efforts aim to ensure that the population recovers to previous levels.



Saiga antelopes are related to a wide range of other species of antelope.

The diagram shows the phylogenetic relationships between some antelopes. This diagram was produced using data from analysis of a protein.



(i) Explain how this diagram indicates that saiga antelopes are more closely related to *Antilope* than to *Antidorcas*.

(2)

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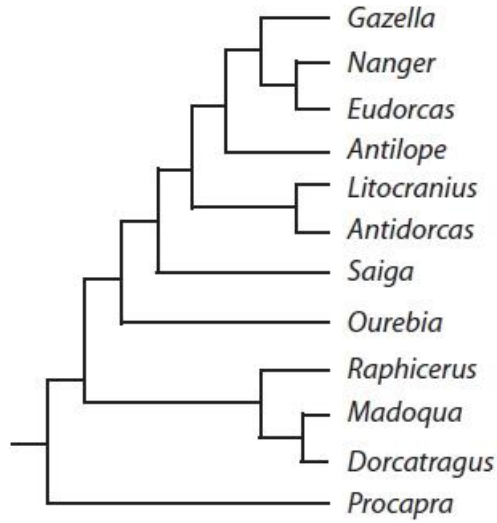
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(ii) This is a more recent classification diagram based on a study of the mitochondrial genomes of antelopes.



Deduce how this study led to different opinions about the relationship between *Saiga* and *Antilope*.

(3)

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(Total for question = 5 marks)

Q38.

Answer the question with a cross in the box you think is correct . If you change your mind about an answer, put a line through the box and then mark your new answer with a cross .

The bee orchid, *Ophrys apifera*, is pollinated by a species of bee, *Eucera longicornis*, that is found in parts of the UK.

Males of this species of bee mistake the flower for a female bee.

The bee orchid can also self-pollinate.



The niche of *E. longicornis* is that it

- A feeds on the orchid
- B is found in the same location as the orchid
- C looks like the orchid flower
- D pollinates the orchid

(1)

(Total for question = 1 mark)

Q39.

Conservation programmes are used to save endangered species.

The Scottish wildcat, shown in the photograph, is a subspecies of the European wildcat, *Felis silvestris silvestris*.



The Cairngorms Wildcat Project estimates that there are 150 breeding pairs left, but the Scottish Wildcat Association believes that only 35 cats remain.

A conservation group proposed that a captive breeding programme, and the relocation of Scottish wildcats, would be necessary to prevent extinction.

Explain how molecular phylogeny could be used to determine the relationships between the Scottish wildcat and other subspecies of European wildcat.

(2)

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(Total for question = 2 marks)

Mark Scheme

Q1.

Question Number	Answer		Additional Guidance	Mark
	Description of adaptation	Type of adaptation shown by the wasp		
	(knocking its body to signal food)	Behavioural (1)		
	(the stinger)	Anatomical (1)		(2)

Q2.

Question Number	Answer	Mark
(i)	<p>The only correct answer is A - ligaments only</p> <p><i>B is not correct because the tendons do not join bones to bones in the elbow joint</i></p> <p><i>C is not correct because the tendons do not join bones to bones in the elbow joint</i></p> <p><i>D is not correct because the ligaments do join bones to bones in the elbow joint</i></p>	(1)

Question Number	Answer	Mark
(ii)	<p>The only correct answer is D rows 3 and 4</p> <p><i>A is not correct because the tendons showing a change is not a change in genotype</i></p> <p><i>B is not correct because the tendons also show a physiological adaptation</i></p> <p><i>C is not correct because the tendons showing a change is not a change in genotype</i></p>	(1)

Question Number	Answer	
* (iii)	<p>Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant.</p> <p>Indicative content Valid because:</p> <ul style="list-style-type: none"> • {sufficient replicates / 12 individuals} used and a mean calculated • All same gender • Means of both heart rate and blood lactate agree with conclusion • Spread of data (standard deviation / error bars) between cycling and running does not overlap <p>Not valid because:</p> <ul style="list-style-type: none"> • Insufficient / only 12 individuals involved • Insufficient detail relating to the athletes e.g. they maybe athletes that focus on different sports/have done more than one previous triathlon / more experienced • The three disciplines are always done in the same order / different distances covered • Spread of cycling data (standard deviation / error bars) for blood lactate overlaps with swimming • As no time allowed to recover between sports, some of blood lactate shown for cycling could have been produced during swimming • Agree or not agree with conclusion 	(6)

			Additional Guidance
Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Considers one area only e.g. comparing mean data or spread of data only Conclusion based on only one set of data or only one sport considered e.g. cycling is most demanding
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Considers both a valid and an invalid aspect e.g. relevance of spread of data for lactate concentrations overlap in some cases or elements of the study Conclusion given that takes both valid and invalid aspects into account
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	Considers both a range of valid and invalid aspects A conclusion based on a range of considered evidence

Q3.

Question Number	Indicative content
	<p>Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p>Section of relevant data</p> <ul style="list-style-type: none"> • higher rate of mutations than in {slowly evolving fish / sticklebacks} • relatively high rate of mutations that change amino acids compared to slowly evolving fish • low rate of gene duplication in slowly evolving fish / high rate of gene duplication in cichlid fish • higher rate of mutations in regulatory sequences in cichlid fish • variety of habitats available providing different selection pressures <p>Consequences of data described</p> <ul style="list-style-type: none"> • more {amino acid changes / gene duplications} the greater number of alleles in gene pool • altered amino acids result in altered protein function • changes in regulatory sequences allow for different gene expression in tissues etc • duplicated genes can be used for new functions without loss of original function / polygenic phenotypes • variety of habitats provide a number of niches suitable for cichlid fish with different adaptations to exploit <p>Linkages made to rate of evolution</p> <ul style="list-style-type: none"> • example of an altered protein function e.g. enzymes that work at different pH / temperature tolerance • development of new phenotypes • {new enzymes/ different mouth shapes} allow new food types to be exploited • changes in {pigmentation / mouth shape} allow speciation

Level	Mark	Descriptor	Additional guidance
Level 0	Marks	No awardable content	
Level 1	1-3	<p>Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made.</p> <p>Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.</p>	<p>At least one relevant piece of data described e.g. higher mutation rate.</p> <p>A consequence described for the data – e.g. linking mutations to protein structure</p> <p>Basic clear conclusion attempted e.g. different proteins are produced</p>
Level 2	4-6	<p>Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts.</p> <p>Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures.</p> <p>The discussion shows some linkages and lines of scientific reasoning with some structure.</p>	<p>At least two pieces of relevant data referred to.</p> <p>Consequences of at least two pieces of data explained</p> <p>Linkages made to evolution of the fish e.g. changes in phenotype</p>
Level 3	7-9	<p>Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts.</p> <p>Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.</p> <p>The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p>	<p>At least three pieces of relevant data referred to</p> <p>Consequences of each piece of data explained</p> <p>Linkages to evolution discussed, e.g. the types of adaptations that may arise due to mutations</p>

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following: <ul style="list-style-type: none"> it is found {in one location / only in Scotland} (1)	DO NOT ALLOW habitat	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: <ul style="list-style-type: none"> increases (genetic diversity)/increases size of gene pool (1) because of introduction of {new/different} alleles (into the population) (1) 	ALLOW increase variety of alleles ALLOW maintain genetic diversity	(2)

Q5.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to: <ul style="list-style-type: none"> no (in row two) (1) some (in row five) (1) 		(2)

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	A answer that makes reference to the following: <ul style="list-style-type: none"> {alternative form / different form / version / variation} of a gene (1) 	IGNORE type of gene	1

Question Number	Answer	Additional Guidance	Mark
(ii)	<ul style="list-style-type: none"> correct use of Hardy-Weinberg equation (1) correct calculation of probability of each homozygote (1) correct answer (1) 	<p><u>Example of calculation</u> $p^2 + 2pq + q^2 = 1$</p> <p>$p^2 =$ either 0.185 or 0.325 $q^2 =$ either 0.325 or 0.185</p> <p>or</p> <p>$2pq = 0.43 \times 0.57 \times 2 = 0.4902$</p> <p>frequency = 50.98 % / 51% (which is greater than 50%)</p> <p>Correct answer with no working gains full marks</p>	3

Q7.

Question Number	Answer	Mark
(i)	B 252 million years ago	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> (sea) ice is a selection pressure for AFPs / AFPs are advantageous (only) when there is (sea) ice (1) so AFPs are likely to have { appeared / increased in frequency } during an ice age (1) the only ice ages since the existence of the ray-fin fish are the Quaternary and Karoo (1) therefore ray-fin fish producing AFPs are likely to have evolved { in the last 2.6 million years / between 260 and 360 million years ago } (1) 	<p>ALLOW AFPs allow fish to survive the ice age</p> <p>ALLOW during the Karoo / Quaternary (ice age)</p>	(3)

Q8.

Question Number	Answer	Additional guidance	Mark
(i)	<ul style="list-style-type: none"> • $N(N-1)$ is calculated (1) • sum of $n(n-1)$ is calculated (1) • correct value for diversity index calculated (1) 	Example of calculation $41 \times 40 = 1640$ 480 $3.4 / 3.42$ Correct answer with no working gains full marks	(3)

Question Number	Answer	Mark
(ii)	An explanation that makes reference to the following: <ul style="list-style-type: none"> • the value will decrease (1) • because there will be fewer species present (1) 	(2)

Q9.

Question Number	Indicative content Mark
	<p>Answers will be credited according to candidate's knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p>The diversity will reduce due to increased self-pollination</p> <p>Populations that self-pollinate will still produce some variation in their offspring</p> <p>This variation will be reduced as only one parents' alleles are used</p> <p>Genetic drift may occur</p> <p>Similarities to <i>E. longicornus</i> may not be as obvious</p> <p>Because there is no advantage / selection pressure to look like a bee</p> <p>Chance of different gene pool</p> <p>Leading to formation of two new species</p> <p>The lack of <i>E. Longicornus</i> in areas of the UK will increase the chance of new species of bee orchid developing there</p>

Level	Marks		Additional Guidance
0	0	No awardable content	
1	1-2	<p>An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information.</p> <p>The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.</p>	<p>Reduced biodiversity - less pollination by bees</p> <p>Fewer bees mean that more orchids will self-pollinate</p>
2	3-4	<p>An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.</p> <p>The explanation shows some linkages and lines of scientific reasoning with some structure.</p>	<p>Self-pollination will cause reduced diversity</p> <p>Change in allele frequencies in the population</p>
3	5-6	<p>An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.</p> <p>The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.</p>	<p>Idea of genetic drift - loss of alleles from populations</p> <p>If not pollinated by bees, alleles leading to that adaptation no longer an advantage</p> <p>Phenotype may change - may result in new species evolving Areas where there are fewer bees will be more likely to have new orchid species evolving</p>

Q10.

Question Number	Answer	Additional Guidance	Mark
	<ul style="list-style-type: none"> • correct values calculated for p and q (1) • correct calculation of proportion of heterozygotes (1) • correct calculation of number of heterozygotes in the population (1) 	<p><u>Example of calculation</u></p> <p>$p = 0.99$ $q = 0.01$</p> <p>$2pq = 2 \times (0.99 \times 0.01) = 0.0198$</p> <p>$0.0198 \times 17\,020\,000 = 336\,996$ carriers</p> <p>Correct answer with no working gains full marks</p>	(3)

Q11.

Question Number	Answer	Additional Guidance	Mark
	<ul style="list-style-type: none"> • correct use of Hardy-Weinberg equation (1) • correct calculation of allele frequencies (1) • correct probability of heterozygote frequency calculated (1) 	<p><u>Example of calculation</u></p> <p>$p^2 + 2pq + q^2 = 1$</p> <p>$q = 0.020$ and $p = 0.980$</p> <p>$2pq = 2 \times (0.98 \times 0.02)$</p> <p>3.92% / 3.9% / 0.0392 / 0.039</p> <p>ALLOW $\frac{49}{1250}$ as a fraction for probability</p> <p>Correct answer with no working gains full marks</p> <p>ALLOW 2 marks for correct allele frequencies alone</p>	(3)

Q12.

Question Number	Answer	Additional guidance	Mark
	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> • (because) there are {more similarities / fewer differences} between the Archaea and the Eukaryota (1) • (because) there are {fewer similarities / more differences} between the Archaea and the Bacteria (1) • two similarities between Archaea and Eukaryota (from table) described (1) • (so) the more recently they have evolved from a common ancestor (1) 	<p>ALLOW correct number of similarities / differences for Archaea and Eukaryota</p> <p>ALLOW correct number of similarities / differences for Archaea and Bacteria</p> <p>e.g. not inhibited by streptomycin/ methionine required for starting protein synthesis / transcription factors required for transcription</p>	(3)

Q13.

Question Number	Answer	Additional Guidance	Mark
(1)	<p>A description that makes reference to</p> <ul style="list-style-type: none"> • (counting) the number of different species (1) • (counting) number of individual per species (1) 	<p>ALLOW measure species richness</p> <p>ALLOW determined population sizes</p>	(2)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>An answer that makes reference to</p> <ul style="list-style-type: none"> appropriate calculation e.g. <ul style="list-style-type: none"> percentage of world {plants / vertebrates / total} found in Madagascar or <ul style="list-style-type: none"> percentage of {plants / vertebrate } in Madagascar that are endemic to Madagascar e.g. or <ul style="list-style-type: none"> percentage of world {plant / vertebrates / total} endemic to Madagascar or <ul style="list-style-type: none"> density of {plant / vertebrates / total} on {Madagascar / Earth} species density of {animals / plants} in Madagascar is higher than for the Earth many of the species found in Madagascar are not found anywhere else 	<p>4% of plants, 3.6% of vertebrates or 4% of the combined total</p> <p>80.9% plants 78.1% of vertebrates endemic</p> <p>3.2% of plants, 2.8% of vertebrates or 3.2% of the combined total</p> <p>ALLOW a large number of species relative to the area</p>	(3)

Q14.

Question Number	Answer	Additional Guidance	Mark
	<p>An answer which makes reference to the following:</p> <ul style="list-style-type: none"> (behavioural) slow moving/sleep for long periods (1) (physiological) slow metabolism (1) (anatomical) hooked claws (1) 	ALLOW sleep for 15 hours	(3)

Q15.

Question Number	Indicative content
	<p>Answers will be credited according to candidate's knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <p>Species number may increase due to:</p> <ul style="list-style-type: none">• Fragmentation of habitat / geographical isolation• Different selection pressures on populations of <i>C. hoffmanni</i>• Different allele frequencies within separate populations• Evolution leading to formation of new species <p>Species number may decrease due to:</p> <ul style="list-style-type: none">• <i>B. pygmaeus</i> is currently critically endangered• Only one population• Therefore could be vulnerable to inbreeding depression• At risk of natural disaster, disease, predation etc• Therefore may become extinct

Level	Marks		Additional Guidance
0	0	No awardable content	
1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Geographical isolation. <i>B. pygmaeus</i> is currently critically endangered. <i>C. hoffmanni</i> becoming more than one species or <i>B. pygmaeus</i> becoming extinct
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	<i>C. hoffmanni</i> Different habitats with different selection pressures leading to natural selection. Or <i>B. pygmaeus</i> has only one population / endemic to one island
3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	(Must consider both species) <i>C. hoffmanni</i> populations accumulate different allele frequencies and develop into different species. <i>B. pygmaeus</i> more vulnerable to becoming extinct with reasons.

Q16.

Question Number	Answer	Additional Guidance	Mark
(i)	A answer that makes reference to the following: <ul style="list-style-type: none"> the area inhabited by a particular { species / organism } (1) 		(1)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>An answer that makes reference to the following:</p> <ul style="list-style-type: none"> • biodiversity {measured / compared} using a diversity index (1) • species richness (assessed) (1) • genetic diversity of {populations / species} (1) • presence of any {endemic / rare} species (1) 	<p>ALLOW count the number of different species in an area</p> <p>ALLOW endangered species / species at risk of extinction</p>	(4)

Q17.

Question Number	Answer	Additional guidance	Mark
	<ul style="list-style-type: none"> • found only in one geographical location (1) 	ALLOW one area of the world	(1)

Q18.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to</p> <ul style="list-style-type: none"> • determine the sequence of amino acids (for trypsin) • determine the number of {differences / similarities} in sequences (of amino acids) between species • the greater the number of differences the less closely related the species are 	<p>ALLOW differences and similarities in primary structure</p> <p>ALLOW more similarities more closely related</p> <p>ALLOW greater difference in sequence longer the time from a common ancestor</p>	(3)

Q19.

Question Number	Answer	Additional guidance	Mark
	<p>An explanation that makes reference to four of the following:</p> <ul style="list-style-type: none"> • mutation leads to { variation within the population of grass snakes / (snakes with) different colour or markings } (1) • (natural selection led to) those snakes which were better camouflaged surviving to reproduce (1) • (therefore) giving rise to two populations with differing allele frequency (1) • (as the result of natural selection) the two populations became reproductively isolated (1) • sympatric speciation (in the context of new species developing in the same habitat) (1) 	<p>ALLOW separate gene pools develop or a change in allele frequency</p> <p>ALLOW can no longer breed with each other</p>	(4)

Q20.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation which makes reference to the following:</p> <ul style="list-style-type: none"> • they are no longer able to interbreed to produce fertile offspring (1) • because populations have become reproductively isolated (1) 		(2)

Question Number	Answer	Mark
(ii)	<p>D - The role of <i>C. hoffmanni</i> in its environment</p> <p><i>The only correct answer is D</i></p> <p><i>A is not correct because the area where C. hoffmanni is found is not a description of niche</i></p> <p><i>B is not correct because the preferred diet of C. hoffmanni is not a description of niche</i></p> <p><i>C is not correct because the risk of C. hoffmanni becoming extinct is not a description of niche</i></p>	(1)

Q21.

Question Number	Answer	Mark
	<p>B – cannot produce fertile offspring</p> <p><i>The only correct answer is B</i></p> <p><i>A is not correct because the populations of the same species can be geographically isolated</i></p> <p><i>C is not correct because individuals of the same species can have different coloured fur</i></p> <p><i>D is not correct because a species may occupy a different niche</i></p>	(1)

Q22.

Question Number	Answer	Mark
(i)	<p>A - They are also found in other locations</p> <p><i>The only correct answer is A</i></p> <p><i>B is not correct because they are not at risk of extinction refers to endangered not endemic</i></p> <p><i>C is not correct because the term endemic is not related to competition</i></p> <p><i>D is not correct because the term endemic is not related to population size</i></p>	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<ul style="list-style-type: none"> natural selection <p>(1)</p>	ALLOW (allopatric) speciation or reproductive isolation.	(1)

Q23.

Question Number	Answer	Mark
	<p>The only correct answer is – C Eurasian badger and South Asian badger as they belong to the same species</p> <p>A is incorrect because the Asian badger and the South Asian badger are unable to produce fertile offspring</p> <p>B is incorrect because the Eurasian badger and Asian badger are unable to produce fertile offspring</p> <p>D is incorrect because the Japanese badger and the south Asian badger are unable to produce fertile offspring</p>	(1)

Q24.

Question Number	Answer	Additional guidance	Mark
	<p>An answer that makes reference to the following</p> <ul style="list-style-type: none"> • Hardy-Weinberg equation stated (1) • correct calculation of frequency of homozygous recessive individuals (1) • correct calculation of frequency of dominant and recessive alleles (1) 	<p>Example of calculation</p> $p^2 + 2pq + q^2 = 1.0$ $q^2 = 102 \div 200 = 0.51$ <p>Dominant allele = 0.29 Recessive allele = 0.71</p> <p>Correct answer with no working gains full marks</p>	(3)

Q25.

Question Number	Answer	Mark
	<p>C - anatomical, behavioural and physiological</p> <p><i>The only correct answer is C</i></p> <p>A is incorrect because there is also a physiological adaptation</p> <p>B is incorrect because there is also a behavioural adaptation</p> <p>D is incorrect because there is also an anatomical adaptation</p>	(1)

Q26.

Question Number	Answer	Mark
	<p>B - Eukaryota</p> <p><i>The only correct answer is B</i></p> <p>A is incorrect because the electron micrograph has a nucleus and other membrane bound organelles so must be a eukaryote</p> <p>C is incorrect because the electron micrograph has a nucleus and other membrane bound organelles so must be a eukaryote</p> <p>D is incorrect because the electron micrograph has a nucleus and other membrane bound organelles so must be a eukaryote</p>	(1)

Q27.

Question Number	Answer	Mark
(i)	<p>C – only Archaea and Bacteria</p> <p><i>The only correct answer is C</i></p> <p>A is not correct because Eukaryota are not prokaryotic</p> <p>B is not correct because Bacteria are also prokaryotic</p> <p>D is not correct because Archaea are also prokaryotic</p>	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>A description that makes reference to four of the following:</p> <ul style="list-style-type: none"> • presence of a cell wall (1) • circular DNA / plasmids (1) • {small / 70S} ribosomes (1) • pili / flagellum (1) • capsule / mesosome (1) 		(4)

Q28.

Question Number	Answer	Additional guidance	Mark
(i)	<p>An explanation that makes reference to three of the following</p> <ul style="list-style-type: none"> many of the elephants with tusks were killed (for their ivory) / large percentage of population do not have tusks (1) elephants without tusks were more likely to survive and breed (1) therefore passing on alleles for not having tusks (1) increasing the frequency of homozygous recessives in the population (1) 	ALLOW converse	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>A description that makes reference to the following</p> <ul style="list-style-type: none"> calculate the {allele frequencies/ number of dominant and recessive alleles} (in the population in Mozambique) (1) (regular) sampling over a period of time (1) 		(2)

Q29.

Question Number	Answer	Additional guidance	Mark						
(i)	Correct completion of the table <table border="1" style="margin-left: auto; margin-right: auto;"> <tr><td>n(n-1)</td></tr> <tr><td>2</td></tr> <tr><td>56</td></tr> <tr><td>0</td></tr> <tr><td>72</td></tr> <tr><td>6</td></tr> </table>	n(n-1)	2	56	0	72	6	All figures need to be correct	(1)
n(n-1)									
2									
56									
0									
72									
6									

Question Number	Answer	Additional guidance	Mark
(ii)	<ul style="list-style-type: none"> • correct calculation of $N(N-1)$ (1) • correct calculation of D (1) 	<u>Example of calculation</u> $N(N-1) = 23 \times 22 = 506$ $\Sigma n(n-1) = 136 \quad 506 \div 136$ $D = 3.72$ ALLOW 3.7 ALLOW ecf from 7(a)(i) Correct answer without working gains full marks	(2)

Q30.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to the following: <ul style="list-style-type: none"> • comparing similarities and differences in {DNA/proteins} (1) • comparison of {nucleotide sequences / amino acid sequences} (1) • the greater the number of differences, the more likely they are to be reproductively isolated (1) 	ALLOW RNA ALLOW If sequences seen on one side but not seen on the other.	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	<p>A description that makes reference to the following:</p> <ul style="list-style-type: none"> • mutations result in production of new alleles (1) • selection pressures cause the {alleles/mutations} to be advantageous (1) • more individuals with the advantageous alleles survive and reproduce (1) • after time, the population would not be able to reproduce with other badger species to produce fertile offspring (1) 	ALLOW different alleles	(4)

Q31.

Question Number	Answer	Mark
(i)	<p>The only correct answer is B - $6.7 \mu\text{m}$</p> <p><i>A is not correct because did not use calculation $20\,000 \mu\text{m} \div 3000$</i></p> <p><i>C is not correct because did not use calculation $20\,000 \mu\text{m} \div 3000$</i></p> <p><i>D is not correct because did not use calculation $20\,000 \mu\text{m} \div 3000$</i></p>	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	<ul style="list-style-type: none"> • correct value for p and q • correct proportion of heterozygotes ($2pq$) • correct number of heterozygotes 	<p><u>Example of calculation</u> ALLOW 0.2 and 0.8 either way round</p> $2pq = 2 \times (0.8 \times 0.2) = 0.32$ <p>number of heterozygotes = $2pq \times 600 = 192$ Correct answer with no working scores full marks</p>	(3)

Question Number	Answer
* (iii)	<p>Answers will be credited according to candidate's knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.</p> <p>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.</p> <ul style="list-style-type: none">• sickle cell anaemia is more frequent in those areas where malaria is also found (as shown on the maps)• highest proportions of populations with allele for sickle cell anaemia are in areas where there is malaria• the Yoruba people live in an area where <i>P.falciparum</i> is found• malaria can be fatal and acts as a selection pressure• individuals heterozygous for sickle cell anaemia more likely to survive malaria• these individuals pass on alleles for sickle cell anaemia to their offspring• over time the number of individuals in the population with alleles for sickle cell anaemia has increased

Level	Marks	Descriptor	Additional guidance
0		No awardable content	
1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	e.g. 9-12% Yoruba have sickle cell allele / Malaria and Sickle cell anaemia are found in the same place OR Heterozygotes resistant to malaria
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of more than one piece of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Two from level 1 Malaria is a selection pressure
3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of all pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Individuals with sickle cell allele survive malaria and pass on allele to offspring. Over time frequency of sickle cell allele increases in Yoruba population

Q32.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: <ul style="list-style-type: none"> (species richness) measures number of species (in a habitat) (1) (heterozygosity index) is a measure of genetic diversity within a { species / population } (1) 	ALLOW proportion of heterozygous individuals in a population / formula for heterozygosity index	(2)

Q33.

Question Number	Answer	Additional guidance	Mark
	<ul style="list-style-type: none"> a group of organisms that can interbreed to produce fertile offspring 	ALLOW 'breed', 'reproduce', 'mate' for 'interbreed'	(1)

Q34.

Question Number	Answer	Additional Guidance	Mark
(i)	<ul style="list-style-type: none"> correct values for p and q (1) value for 2pq calculated (1) correct number of people calculated (1) 	<p>Example of calculation</p> <p>p = 0.9975 and q = 0.0025 OR p = 0.9976 and q = 0.0024 ALLOW opposite values for p and q</p> <p>2pq = 0.0048 to 0.0050</p> <p>319 200 to 332 500</p> <p>Correct answer with no working gains full marks</p>	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An explanation that makes reference to three of the following:</p> <ul style="list-style-type: none"> because the allele for LGMD2A may undergo mutation (1) because gene flow may cause alleles to be lost or gained from the population (1) due to { natural selection / (changed) selection pressure } (1) because people with the condition may not have children (1) 	<p>ALLOW random mutations to allele</p> <p>ALLOW: immigration / emigration</p> <p>ALLOW confers an advantage / disadvantage</p>	(3)

Q35.

Question Number	Answer	Additional guidance	Mark
	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none"> Hardy-Weinberg equation shows the allele frequency in a population (1) if natural selection is occurring there would be a change in allele frequency over time (1) 	<p>ALLOW reference to change in number of heterozygotes</p>	(2)

Q36.

Question Number	Answer	Mark
	C physiological adaptation	(1)

Q37.

Question Number	Answer	Additional Guidance	Mark
(i)	<p>An explanation which makes reference to the following:</p> <ul style="list-style-type: none"> • (<i>Saiga</i> more closely related to <i>Antelope</i>) because they shared a common ancestor more recently (1) • there are more similarities in the protein (1) 	e.g. similar sequences of amino acids in the protein	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	<p>An answer which makes reference to the following:</p> <ul style="list-style-type: none"> • they are less closely related (1) • DNA { profiling / analysis / comparison } (1) • (detected) more differences in the mitochondrial genome (1) 		(3)

Q38.

Question Number	Answer	Mark
	<p>The only correct answer is – D pollinates the orchid</p> <p>A is incorrect because <i>E. longicornis</i> does not feed on the orchid</p> <p>B is incorrect because the term niche does not relate to the location of an organism</p> <p>C is incorrect because the term niche does not relate to appearance of the organism</p>	(1)

Q39.

Question Number	Answer	Additional Guidance	Mark
	<p>An explanation that makes reference to the following:</p> <ul style="list-style-type: none">• (compare) sequences of {bases in DNA /amino acids in proteins} (1)• the more similarities in common the more closely-related the subspecies (1)	<p>ALLOW nucleotides for bases</p> <p>ALLOW more recently evolved from a common ancestor</p> <p>ALLOW converse statements</p>	(2)