Q1.

4 (a) Explain, **with one example**, how a mutation may affect the phenotype of an organism.

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.....[4]

A mutation of the gene for the β polypeptide chain of haemoglobin can result in sickle cell anaemia, a lethal or near lethal condition.
Only people who are homozygous for this allele have sickle cell anaemia.
All haemoglobin is affected in people who have sickle cell anaemia.
At low oxygen levels red blood cells are distorted (sickle shape) which leads to blockage of capillaries and the destruction of many red blood cells by phagocytosis leading to severe anaemia.

Fig. 4.1 shows the distribution of malaria and the sickle cell allele.

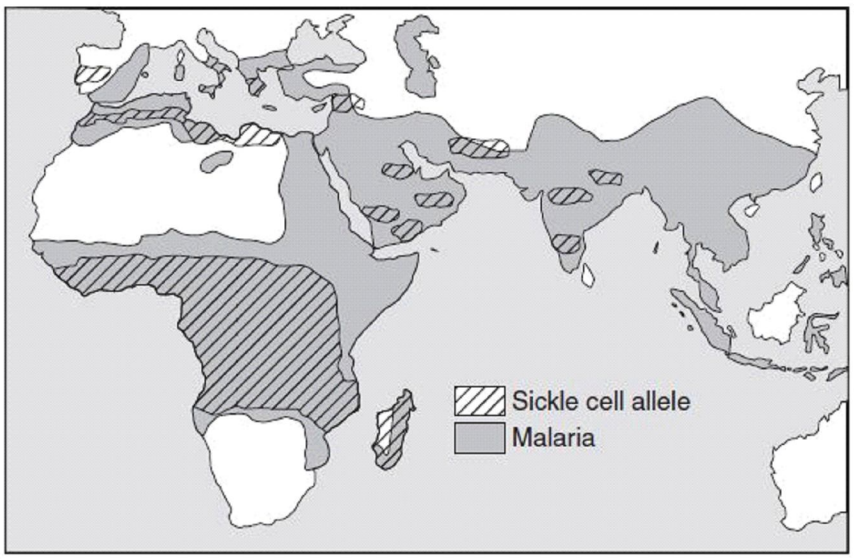

Fig. 4.1

(b) Explain why the sickle cell allele occurs at such high frequencies in some areas.

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.....[4]

[Total: 8]

Q2.

8 (a) Explain what is meant by *artificial selection*.

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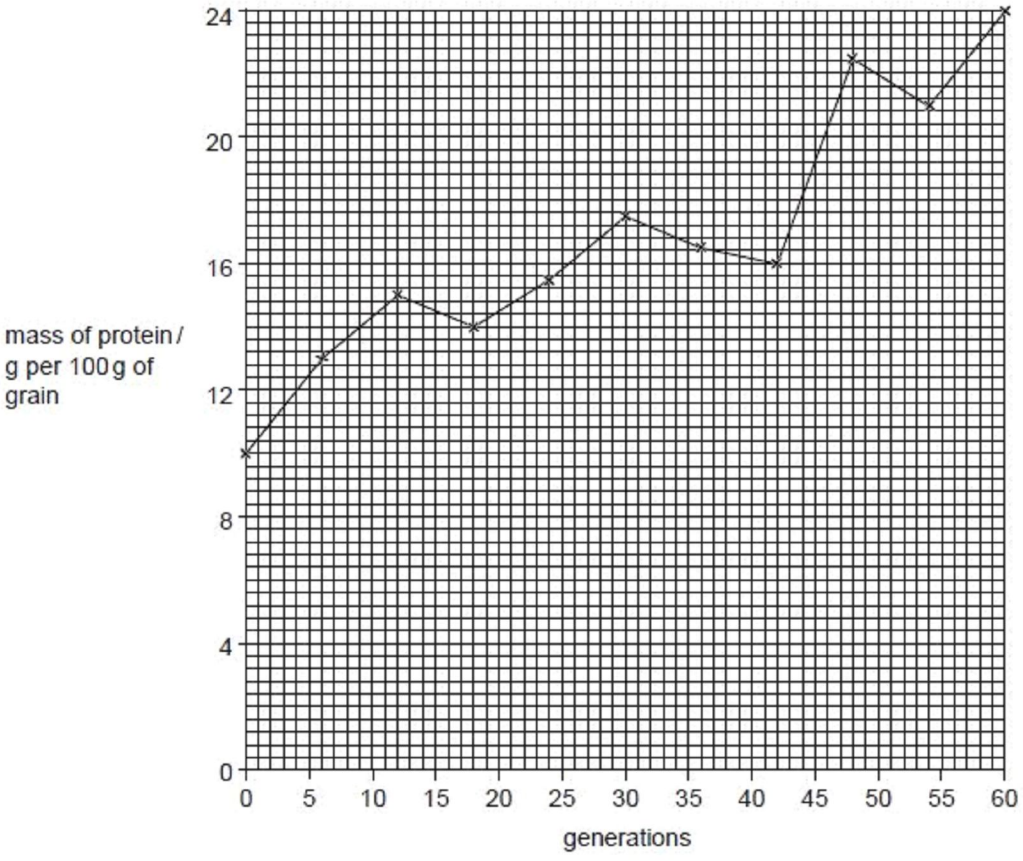
.....[4]

(b) In a plant breeding programme, corn, *Zea mays*, was bred in an attempt to produce a high yield of protein in the grain.

The results of this programme are shown in Fig. 8.1.



(i) With reference to Fig. 8.1, calculate the percentage increase in grain protein by the end of the experiment.

Show your working.

Answer .....% [2]

(ii) Suggest why the protein yield does not increase steadily in each generation.

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.....[2]

[Total: 8]

Q3.

8 The Atlantic herring, *Clupea harengus*, lives in large populations called shoals and may grow up to 40 cm long.

Fig. 8.1 shows the appearance of *C. harengus*.

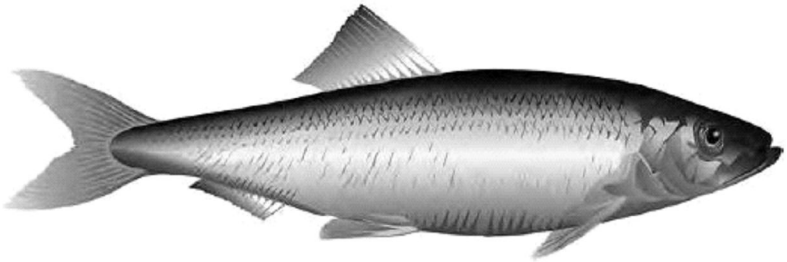


Fig. 8.1

The length of *C. harengus* shows wide variation.

Fig. 8.2 shows the numbers of fish of different lengths in a population of *C. harengus*.

The arrows show the selection pressures, **P** and **S**.

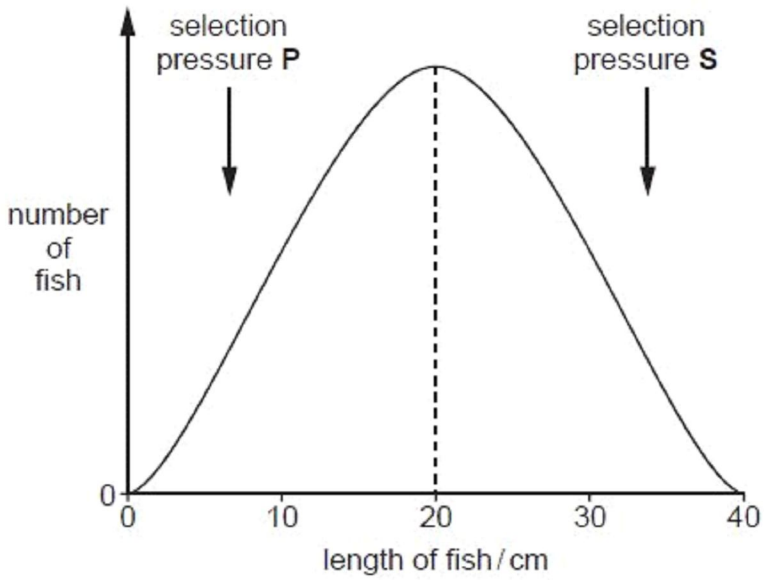
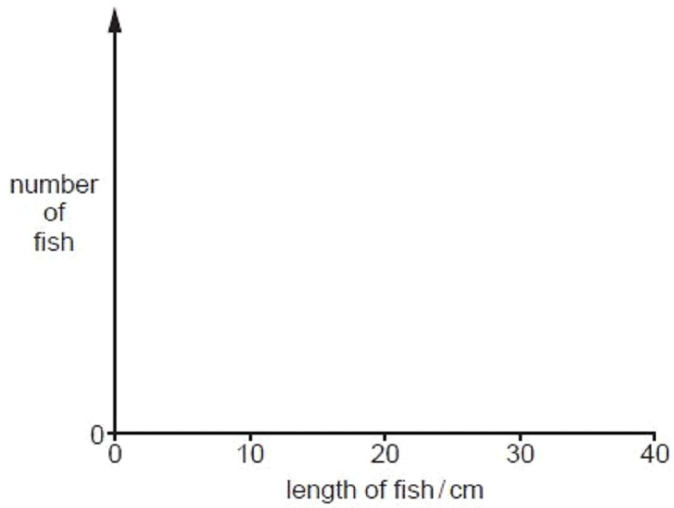


Fig. 8.2

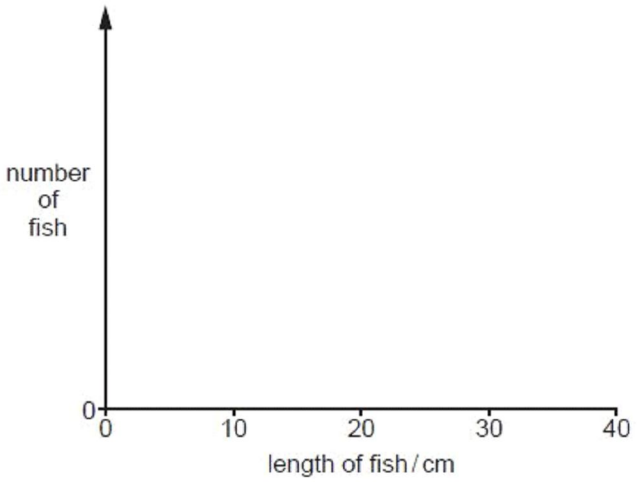
(a) **(i)** Sketch a graph on the axes below to show the distribution of length of *C. harengus*, when selection pressures **P** and **S** operate for a few years.



[2]

(ii) Name this type of natural selection ..... [1]

(b) (i) Sketch a graph on the axes below to show the distribution of length of *C. harengus*, when selection pressure **S** alone operates for a few years.



[2]

(ii) Name this type of natural selection .....[1]

(iii) Suggest two examples of selection pressure **S**.

1. .....

2. .....[2]

[Total: 8]

Q4.

5 Anole lizards are found throughout the Caribbean and the surrounding mainland. There are many species. Each species is found only on one island or a small group of islands, apart from *Anolis carolinensis* which is found in mainland Florida.

Fig. 5.1 shows the distribution of four species of anole lizards.

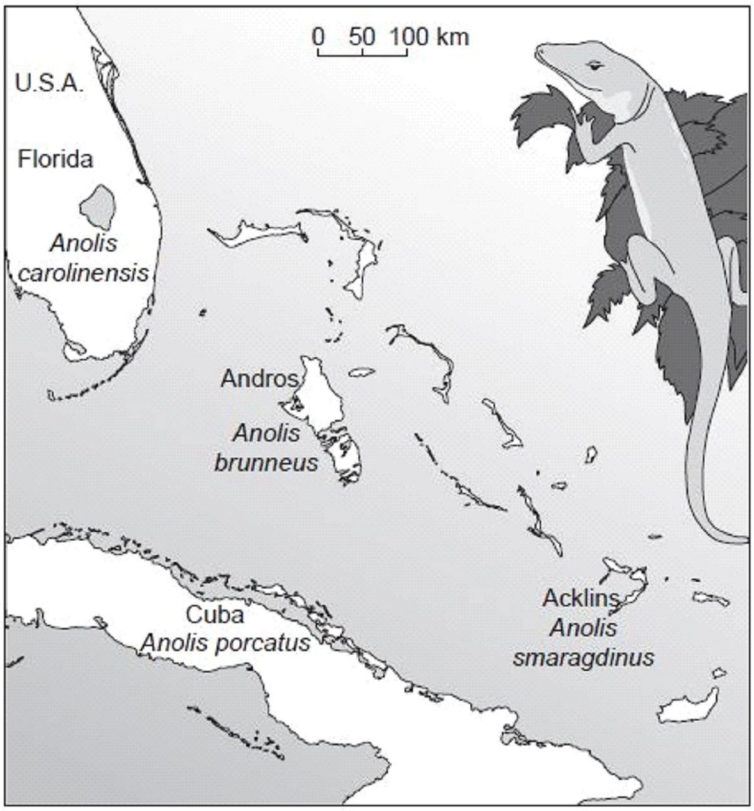


Fig. 5.1

An investigation was carried out into the relationships between these four lizard species, using DNA analysis. The base sequences of a region of mitochondrial DNA from the four species were compared. The results are shown in Table 5.1.

The smaller the number, the smaller the differences between the base sequences of the two species.

	A. brunneus	*A. smaragdinus*	*A. carolinensis*	*A. porcatus*
A. brunneus				
A. smaragdinus	12.1			
A. carolinensis	16.7	15.0		
A. porcatus	11.3	8.9	13.2	

(a) With reference to Table 5.1, state the species to which *A. brunneus* appears to be most closely related.

..... [1]

(b) The researchers put forward the hypothesis that the three species, *A. brunneus*, *A. smaragdinus* and *A. carolinensis*, have originated from three **separate** events in which a few individuals of *A. porcatus* spread directly from Cuba to three different places.

Explain how the results in Table 5.1 support the researchers' hypothesis.

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(c) Explain how a population of *A. porcatus* that became isolated on an island could evolve into a new species.

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[Total: 8]

Q5.

5 The fruitfly, *Drosophila*, has many different species. Three of these species, *Drosophila pseudoobscura*, *D. persimilis* and *D. miranda*, are thought to be closely related.

Samples of these three species were collected from the western United States of America. Fig. 5.1 shows where these species naturally occur.

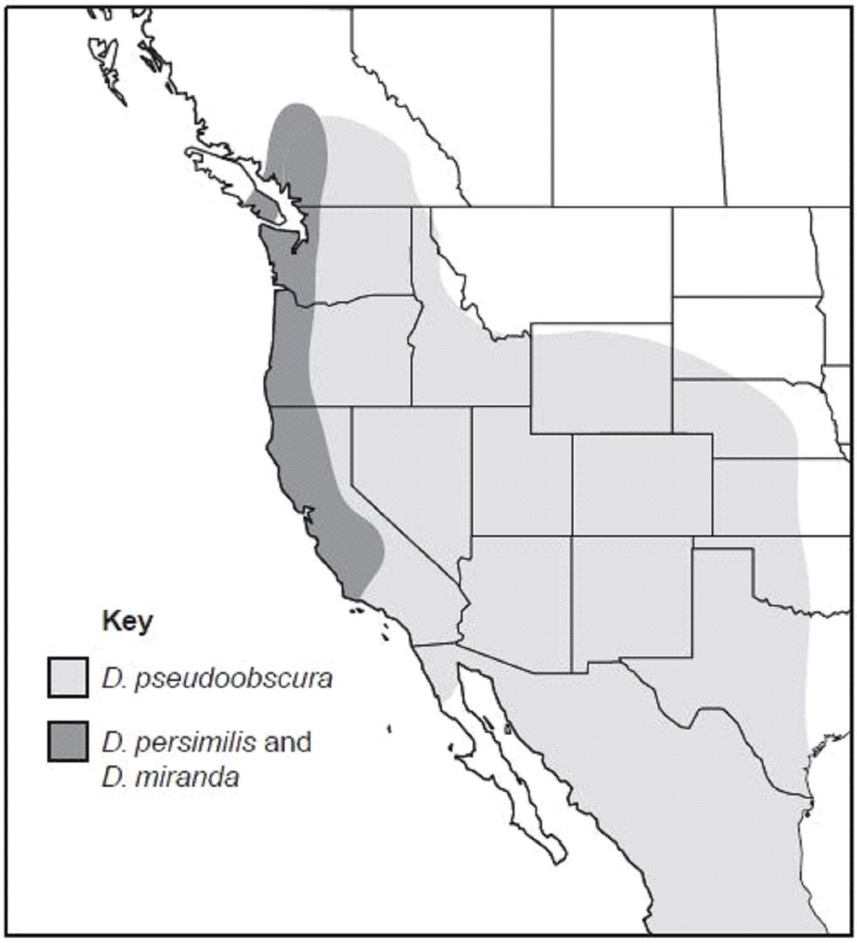

Fig. 5.1

The base sequences of four regions of DNA of each species were sequenced. The divergence of these base sequences in *D. pseudoobscura* and *D. persimilis* from the sequences in *D. miranda* was calculated. The results are shown in Table 5.1.

For Examiner Use

Table 5.1

DNA region	*Drosophila* species	percentage divergence of base sequence from that of *D. miranda*
1	*pseudoobscura*	2.5
	persimilis	2.4
2	*pseudoobscura*	8.1
	persimilis	7.3
3	*pseudoobscura*	2.1
	persimilis	1.7
4	*pseudoobscura*	1.9
	persimilis	1.7

(a) With reference to Table 5.1, describe the evidence that *D. miranda* may be more closely related to *D. persimilis* than to *D. pseudoobscura*.

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..... [2]

(b) Suggest why there is more divergence in some regions of DNA than in others.

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(c) The area where *D. pseudoobscura* is found is separated from the areas where the other two species are found by a high range of mountains.

Explain how the species *D. pseudoobscura* could have evolved from a population of *D. miranda*.

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..... [4]

[Total: 8]

Q6.

8 The hedgehog, *Erinaceus europaeus*, is a small carnivorous mammal native to Northern Europe.

Fig. 8.1 shows a hedgehog.

Fig. 8.1

Hedgehogs were introduced onto a small group of islands off the west coast of Scotland in 1974. The hedgehog population has increased so that there are now over 5000 breeding pairs. These hedgehogs have no natural predators on these islands and their diet consists mainly of bird's eggs.

Fig. 8.2 shows the hedgehog population density in the year 2000.

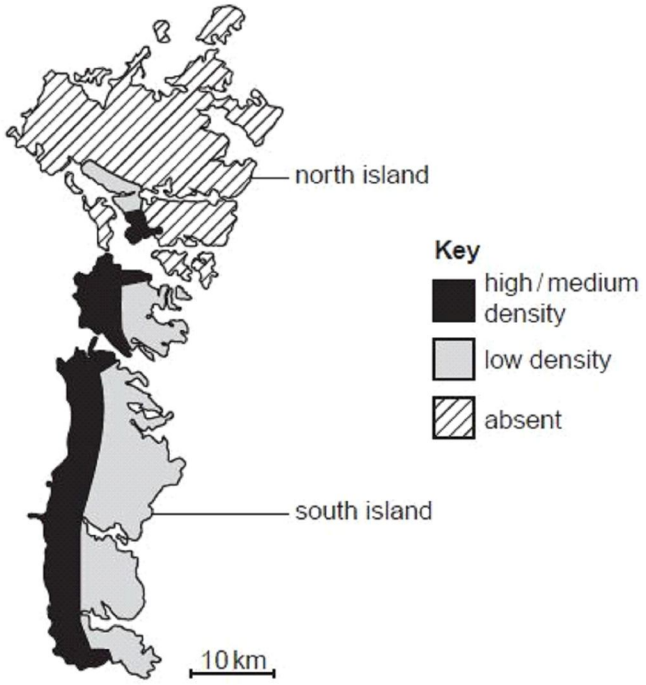

Fig. 8.2

Table 8.1 shows the changes in the populations of the species of birds from 1983 to 2000.

Table 8.1

	breeding pairs in 1983	breeding pairs in 2000	% change in population
north island			
oystercatcher	928	1122	+21
lapwing	1104	1364	+24
redshank	486	733	+51
south island			
oystercatcher	907	1403	+55
lapwing	1869	1287	–31
redshank	1288	760	–41

(a) Using Fig. 8.2 and Table 8.1, describe the relationship between the hedgehog population density and the changes in the populations of **lapwings** and **redshanks**.

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(b) Suggest an explanation for the increase in the oystercatcher population on the south island, despite the increase in the hedgehog population.

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(c) Explain why the population of hedgehogs on one of these islands may eventually become a different species from that on mainland Scotland.

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[Total: 9]

Q7.

8 The following passage is a summary of the main principles of natural selection.

Some of the words have been omitted.

Write the most appropriate term in each space.

Individuals in a population have great ..... potential and yet the numbers in a population remain roughly ..... . This is because many die due to environmental factors and therefore do not reproduce. There is ..... amongst members of a population and those with the features best adapted to the environment survive. They reproduce and pass on their ..... to their offspring. This may lead to a change in the ..... pool of the population and over time may lead to evolutionary change.

[5]

[Total: 5]

Fo
Exami
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Q8.

1 The greenish warbler, *Phylloscopus trochiloides*, is a species of small bird that originated in northern India, on the southern edge of the Himalayan mountain range.

Fig. 1.1 shows a greenish warbler.

Fig. 1.1

Thousands of years ago, populations of the greenish warbler spread around the western and eastern edges of the Himalayan mountain range to establish themselves in north-eastern Europe and Siberia.

- A gradual change in characteristics occurred in these populations, leading to different forms of the greenish warbler.
- One example of gradual change is in the song of the male warbler, which is very distinctive and is used in mating behaviour.
- When greenish warblers from north-eastern Europe meet those from Siberia no mating takes place.
- The greenish warblers from north-eastern Europe and Siberia are now considered to be two separate species.

Fig. 1.2 shows the spread of the greenish warbler.

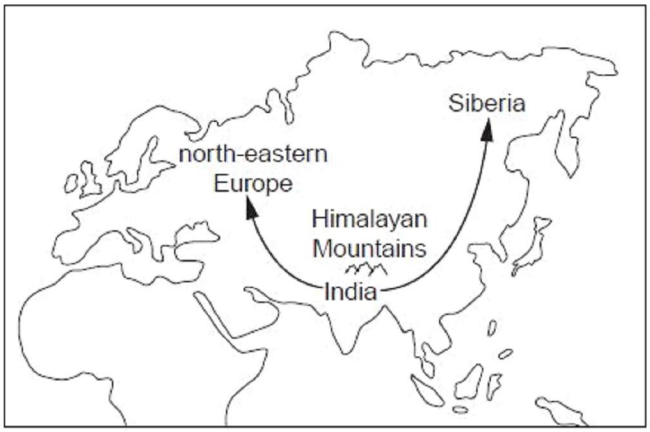

Fig. 1.2

(a) Explain what is meant by the term *species*.

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.....[2]

(b) State the likely isolating mechanism taking place in populations of the greenish warbler.

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(c) Explain how the process of speciation occurred in the greenish warbler populations.

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[Total: 8]

Q9.

1 The seahorse, *Hippocampus,* is an unusual small fish. It gives birth to live young and it is the male rather than the female that becomes pregnant.

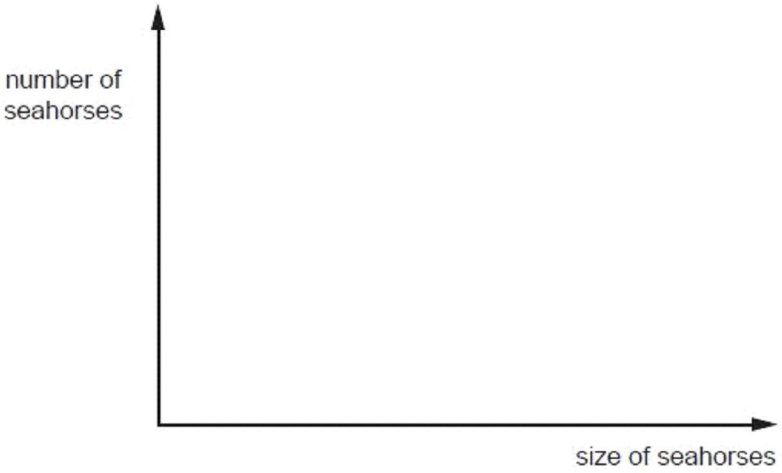
Fig. 1.1 shows a seahorse.

Fig. 1.1

(a) In one species of seahorse, a type of natural selection called disruptive selection occurs. This is where the extreme phenotypes are more likely to survive and reproduce than the intermediate phenotypes.

- Within a population, large females mate with large males and small females mate with small males.
- Few intermediate-sized individuals are produced and they have a low survival rate.

(i) Sketch a graph on the axes below to show the distribution in size of seahorses as a result of disruptive selection.



[2]

(ii) Explain how disruptive selection has been maintained in this species of seahorse.

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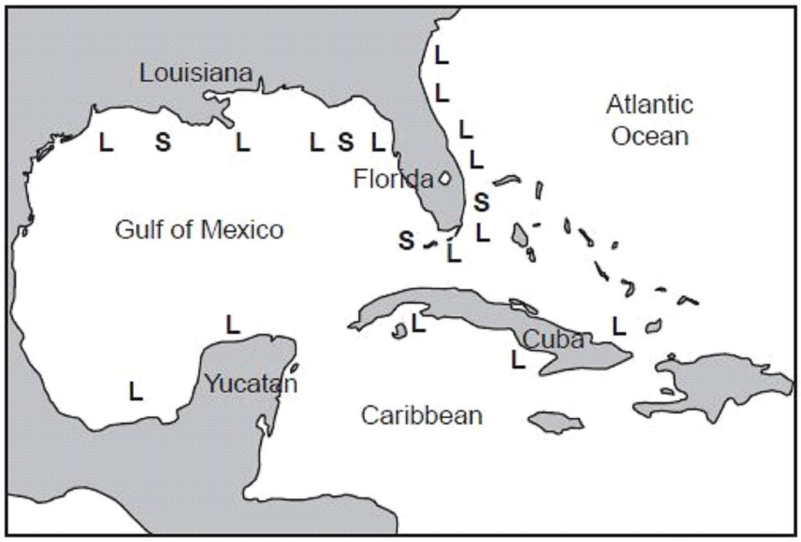
.....[3]

(iii) State the term given to the type of selection where variation in a characteristic is maintained in its existing form over time.

.....[1]

(b) Two different species of seahorse are found in the coastal waters shown in Fig. 1.2.



Key: L = large seahorse *H. erectus* **S** = small seahorse *H. zosterae*

Fig. 1.2

Suggest how these two different species of *Hippocampus* could have arisen.

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.....[2]

[Total: 8]

Q10.

8 Sarawak is an area of south-east Asia that is largely covered by tropical rainforest. Logging has been allowed in large parts of the forest. A study was carried out to estimate the population size of different species of mammals living in the rainforest:

- before logging
- immediately after logging
- two years after logging
- four years after logging.

Table 8.1 shows the results of the study for six species of mammal. Where numbers were too small to measure the population density, the species were recorded as "present".

Table 8.1

mammal	mean number of animals km^{-2}			
	before logging	immediately after logging	two years after logging	four years after logging
marbled cat	present	0	0	0
small-clawed otter	present	0	0	0
giant squirrel	5	1	4	1
treeshrew	10	5	10	38
small squirrel	16	24	104	19
barking deer	3	1	10	present

(a) Calculate the percentage rise in the small squirrel population from before logging to two years after logging.

Show your working.

answer ..... % [2]

(b) Suggest why populations, such as that of the small squirrel, do not increase in size indefinitely.

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(c) Suggest why marbled cats and small-clawed otters became extinct in this area but the other mammals did not.

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[Total: 8]

Q11.

8 The Death Valley region of Nevada in the USA used to have an extensive lake system. Approximately 20 000 years ago the lakes started to dry up and now consist of isolated small pools. Four different species of the desert pupfish have been found living in these pools. Evidence indicates that over 20 000 years ago there was only one species of pupfish living in the lake system.

Fig. 8.1 shows a desert pupfish.

Fig. 8.1

(a) Explain how the change from an extensive lake system to just a few pools could have resulted in the evolution of four new species of desert pupfish.

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(b) State how environmental factors can act as stabilising forces of natural selection in an isolated pool, after the initial evolution of a new species of desert pupfish.

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..... [2]

(c) Suggest what may happen to the desert pupfish if water levels rise and the pools once more form an extensive lake system.

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..... [3]

[Total: 10]

Q12.

5 Four species of desert pupfish have evolved in the Death Valley region of Nevada since the extensive lakes that existed there were reduced to isolated pools 20 000–30 000 years ago.

(a) Explain how the drying up of an extensive lake system to just a few isolated pools could have resulted in the evolution of four new species of desert pupfish.

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(b) Indicate how environmental factors can act as stabilising forces of natural selection in an isolated pool after the initial evolution of a new species.

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.....[3]

(c) Suggest what may happen if water levels rose and the isolated pools once more formed an extensive lake system.

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.....[2]

[Total : 9]

Q13.

4
- There are over 40 Galapagos Islands including the small and isolated island named Daphne Major.
- Only two species of Darwin finches are found on this island.
- Studies were made every year from 1970 to 1989 on the beak size of the island's population of ground finch, *Geospiza fortis*, by measuring the beak length of every bird (Fig. 4.1). Larger finches with larger beaks are better at opening large seeds. From 1976 to 1978 there was a drought and only 15% of the ground finches survived and these did not breed during drought years.

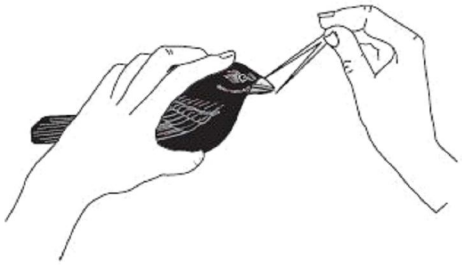

Fig. 4.1

- All finches were reduced in number. The most conspicuous feature of the survivors of the drought years was their large beak size.
- The main environmental consequences of drought is the decline in food supply, mainly seeds. During normal years, many grasses and herbs produce an abundance of small seeds. A few other plants produce a much smaller number of large seeds which are not normally eaten.

(a) Describe how environmental factors appear to have acted, during drought years, on the beak size of finches as an evolutionary force of natural selection.

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.....[3]

Finches with small beaks were found to be smaller than finches with larger beaks.

(b) Explain the stabilizing force of natural selection on the beak size and size of birds in normal years.

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.....[3]

(c) Outline the mechanisms that may have let natural selection lead to the evolution of the thirteen species of Darwin finches now found on the Galapagos Islands.

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.....[2]

[Total : 8]

Q14.

4 In Central America the Isthmus of Panama closed about 3 million years ago creating a land bridge between North and South America. Snapping shrimps on the Caribbean side of the isthmus appear almost identical to those on the Pacific side, having once been members of the same population. When males and females from different sides of the isthmus were put together they snapped aggressively instead of courting. They had become separate species.

An outline of the region is shown in Fig. 4.1.

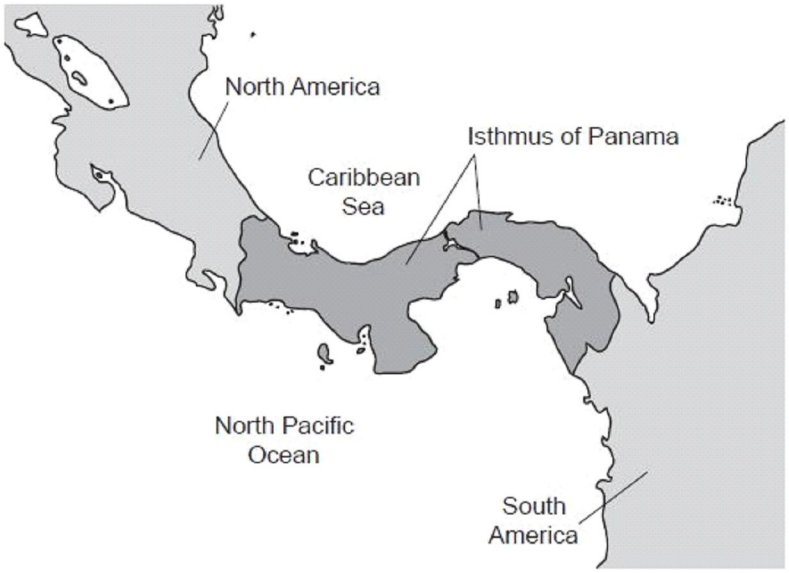

Fig. 4.1

(a) The term species is often used in the context of evolution of new species. Explain the meaning of the term **species**.

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..... [2]

(b) State the likely isolating mechanism and type of speciation taking place.

Isolating mechanism .....

Type of speciation ..... [2]

(c) Explain how the process of speciation occurred in the snapping shrimp population.

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[Total: 8]

Q15.

9 Sickle cell anaemia is a genetic disorder that is caused by the presence of two recessive alleles. It is common amongst people of African origin.

Malaria is a major cause of death in sub-Saharan Africa where 90% of the world's cases occur.

Fig. 9.1 shows the distribution of sickle cell anaemia and malaria in Africa.

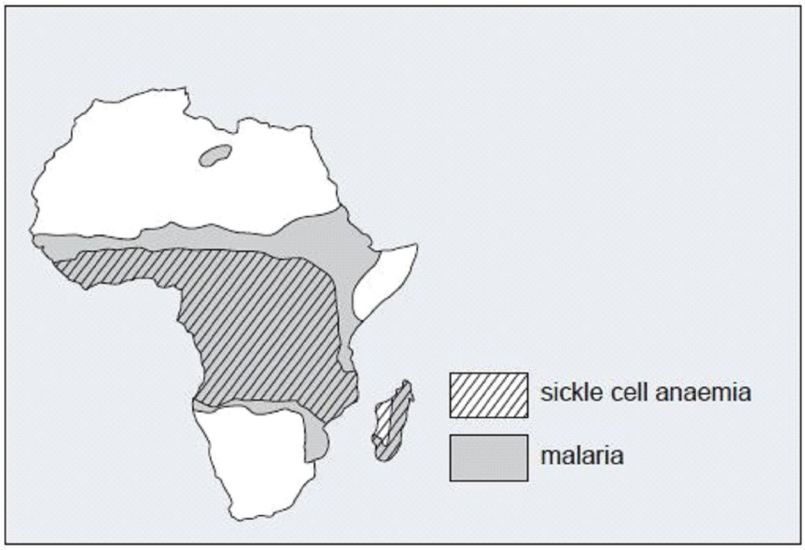

Fig. 9.1

(a) Explain why malaria is found in the areas shown but not in areas such as northern Europe and South Africa.

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..... [2]

(b) With reference to Fig. 9.1, explain the relationship between the distribution of sickle cell anaemia and malaria.

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[Total: 6]

Q16.

2 **(a)** *Asellus aquaticus* is a small freshwater crustacean.

200 *A. aquaticus* were released into a pond where there had previously been none. The pond was favourable for their growth and reproduction.

Describe **and** explain the expected changes in the population size of *A. aquaticus* over the following few months.

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.....[5]

(b) In order for natural selection to occur a population must show phenotypic variation.

Explain why variation is important in natural selection.

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.....[2]

[Total: 7]

Q17.

2 **(a)** A recent study of the house mouse, *Mus musculus*, on the island of Madeira resulted in the following observations.

- There are six distinct populations.
- The mice are associated with human settlements.
- The populations are located in different valleys separated by steep mountains.
- Each population has a different diploid number of chromosomes.

As a result of these observations it has been suggested that speciation is taking place.

Fig. 2.1 is a map of Madeira showing the distribution of the six populations.

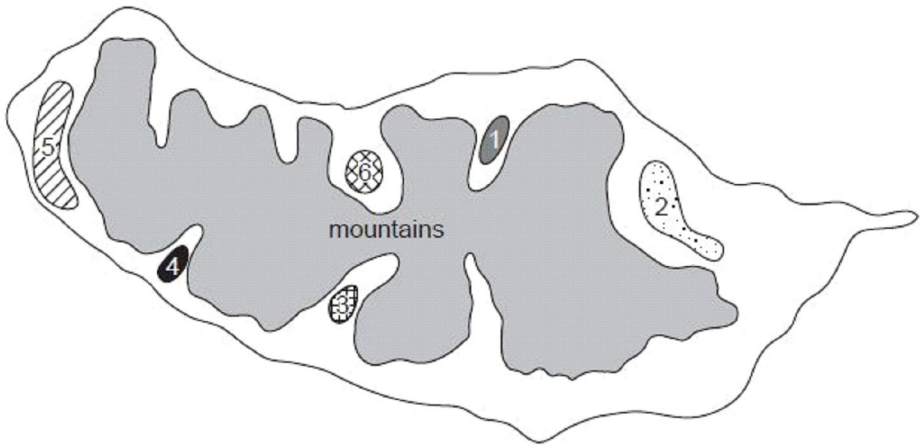

Fig. 2.1

Using the information in Fig. 2.1, state the likely isolating mechanism and the type of speciation taking place.

isolating mechanism .....

type of speciation .....[2]

(b) Explain how speciation is occurring in the house mouse populations of Madeira.

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.....[5]

[Total: 7]

Q18.

6 From 1975 to 1977 one of the Galapagos Islands, Daphne Major, experienced a severe drought. A ground finch, *Geospiza fortis*, feeds on seeds on Daphne Major.

Fig. 6.1 shows the ground finch, *G. fortis*.

Fig. 6.1

- One of the few plants that survived the drought produced large seeds inside tough fruits.
- Many *G. fortis* died during the drought and the population declined from 1400 in 1975 to 190 in 1977.
- The mean beak depth of those *G. fortis* that died was 10.68 mm and the mean beak depth of those that survived was 11.07 mm.
- The mean beak depth of *G. fortis* before the drought was 10.86 mm.

(a) Calculate the percentage decrease in population size between the years 1975 and 1977.

Show all the steps in your calculation and give your answer to the nearest whole number.

Answer ..... % [2]

(b) Suggest why some *G. fortis* were able to survive the drought while others died.

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..... [3]

(c) Natural selection was taking place on Daphne Major.

State the type of natural selection operating on *G. fortis* **during** the drought **and** explain your answer.

type of natural selection .....

explanation .....

..... [2]

[Total: 7]

Q19.

8 Asthma is a disease of the respiratory system.

- During an asthma attack the membranes lining the airways release mucus and become inflamed.
- This causes the muscles of the airways to contract and narrow the lumen of the airways, making breathing difficult.
- Most asthma attacks are triggered by allergens.
- Allergens are harmless substances that, in some people, stimulate an immune response that leads to an allergic reaction.
- There has been a large increase in cases of asthma over the last 40 years.

(a) Many allergens that can trigger an asthma attack are inhaled during normal breathing.

Suggest **two** examples of these allergens.

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.....[2]

(b) Over the past 20 years a study has been carried out on the 261 inhabitants of a remote island in the South Atlantic called Tristan da Cunha.

- There are only seven different family names on the island.
- Half of the islanders displayed symptoms of asthma.
- A gene, *ESE3*, is responsible for the normal deposition of collagen in the walls of the airways.
- When the gene is faulty, too much collagen is produced and this can lead to asthma-like symptoms, making breathing difficult.
- This faulty gene has been found among the inhabitants of Tristan de Cunha.

(i) Collagen is also found in the walls of blood vessels.

State **one** property of collagen that enables it to carry out its main function in the walls of blood vessels and airways.

.....[1]

(ii) Suggest why this form of asthma was very common amongst the population of Tristan da Cunha.

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.....[3]

[Total: 6]

Q20.

8 The following passage is a summary of the main principles of artificial selection.

Some of the words have been omitted.

Write the most appropriate term in each space.

When humans purposefully apply selection ..... to members of a population, the process is known as artificial selection. For example, people have tried to 'improve' their cattle for thousands of years. It is desirable for a dairy farmer to have cows with a high milk yield. The farmer will select cows with high milk yields and mate them with bulls whose ..... have high milk yields. Some of the ..... conferring high milk yield are passed onto their female offspring who are then chosen for breeding. This will continue for many ..... . Artificial selection can have disadvantages such as ..... depression which can lead to infertility. [5]

[Total: 5]

Q21.

2 Mammoths are extinct mammals related to elephants. About three million years ago, the ancestors of mammoths migrated from Africa into Europe and Asia. There, about 1.7 million years ago, the steppe mammoth evolved and became adapted to the cooler conditions. Then, about 700 000 years ago, as the climate changed and the Arctic became much colder, the woolly mammoth evolved.

Woolly mammoths showed a number of obvious adaptations to reduce heat loss, including thick fur, small ears and small tails.

(a) Explain how variation and natural selection may have brought about the evolution of the woolly mammoth from the steppe mammoth.

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(b) A frozen, 43000 year old woolly mammoth was found in Siberia. Its DNA was extracted and sequenced. The sequences of the genes coding for the α and β chains of haemoglobin were compared with those of modern Asian elephants.

The results suggested that, when compared with Asian elephants:

- there was only one different amino acid in the woolly mammoth's α chains
- there were three different amino acids in the woolly mammoth's β chains.

Explain the likely effect of these differences on a molecule of mammoth haemoglobin.

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(c) Scientists synthesised woolly mammoth haemoglobin in order to investigate whether or not the different haemoglobin was part of the mammoth's adaptation to a cold climate.

The affinity of haemoglobin for oxygen is affected by the changes in temperature that can occur in mammals, for example in active muscle tissue or close to the skin surface.

It is advantageous for Arctic mammals to have haemoglobin whose affinity for oxygen is only slightly affected by changes in temperature. This is often achieved by using substances called 'red cell effectors', which bind to haemoglobin.

Fig. 2.1 compares the effect of temperature on the affinity for oxygen of woolly mammoth and Asian elephant haemoglobin, with and without red cell effectors.

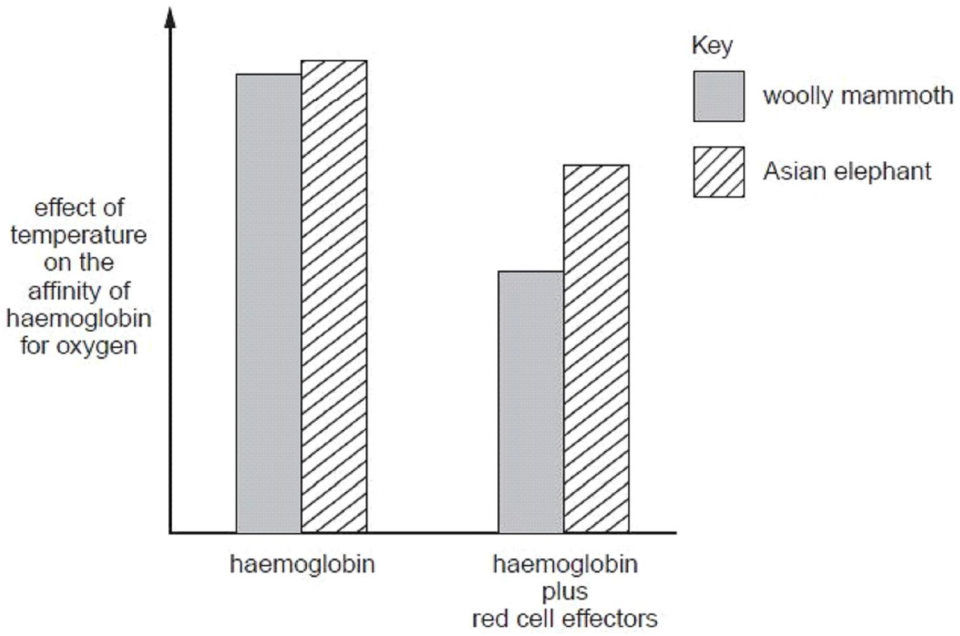

Fig. 2.1

(i) Suggest why it is advantageous for Arctic mammals to have haemoglobin whose affinity for oxygen is only slightly affected by changes in temperature.

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(ii) Explain whether or not Fig. 2.1 provides evidence that woolly mammoth haemoglobin is better adapted for a cold climate than Asian elephant haemoglobin. E

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[Total: 14]

Q22.

2 The evolutionary origin of the four-legged amphibians (such as frogs and toads) from fish has been the subject of much debate for many years. Ex

Among living fish, the rarely-caught coelacanth and the lungfish are thought to be most closely related to these amphibians.

Samples of blood were taken from two coelacanths that were captured recently near Comoros.

The amino acid sequences of the α and β chains of coelacanth and lungfish haemoglobin were compared with the known sequences of amphibian adults and their aquatic larvae (tadpoles). Organisms with more matches in the amino acid sequence of a polypeptide chain share a more recent common ancestor than those with fewer matches.

The comparisons with three species of amphibians, *Xenopus laevis (Xl), X. tropicana (Xt) and Rana catesbeiana (Rc)* are shown in Table 2.1.

Table 2.1

		percentage of matches of amino acid sequence					
		species of amphibian adults			species of amphibian larvae (tadpoles)		
	fish species	*Xl*	*Xt*	*Rc*	*Xl*	*Xt*	*Rc*
α chains	coelacanth	42.0	47.5	no data	45.4	42.6	48.2
	lungfish	40.4	42.1	no data	40.7	39.0	37.9
β chains	coelacanth	42.1	43.2	40.7	52.1	52.1	58.2
	lungfish	44.1	45.9	41.4	47.3	45.9	48.6

(a) (i) Explain whether or not the information in Table 2.1 supports the suggestion that coelacanths and amphibians share a more recent common ancestor than do lungfish and amphibians.

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(ii) Suggest why adults and tadpoles of the same species of amphibian have different amino acid sequences in their haemoglobin.

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(b) Coelacanth haemoglobin has a very high affinity for oxygen, suggesting that coelacanths, which have been captured at depths of between 200 m and 400 m, live in water that has a low concentration of oxygen.

Explain how an environmental factor, such as the low concentration of oxygen in deep water, can act:

(i) as a stabilising force in natural selection

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(ii) as an evolutionary force in natural selection.

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(c) Explain the role of isolating mechanisms in the evolution of new species.

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[Total: 15]

Q23.

5 Deer mice, *Peromyscus maniculatus*, are small rodents that live in North America. Like all mammals, their blood contains haemoglobin which combines with oxygen in the lungs, and unloads its oxygen in respiring tissues.

Deer mice show variation in their genotypes for the genes that code for the α-polypeptide chain of haemoglobin. In most populations of deer mice, the majority of individuals have the genotype A^1A^1, while a smaller number have the genotype A^0A^0.

(a) In mice with the genotype A^1A^1, the amino acid at position 64 in the α-polypeptide chain is aspartic acid. In mice with the genotype A^0A^0, the amino acid at this position is glycine.

Suggest how the change from aspartic acid to glycine in the α-polypeptide chain could have been brought about.

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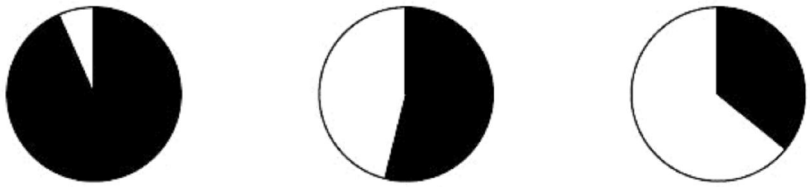
(b) The genotypes of deer mice from three different populations, each living at a different altitude, were analysed. Fig. 5.1 shows the relative proportions of deer mice with aspartic acid (white areas) and glycine (black areas) at position 64 in the α-polypeptide of their haemoglobin.



altitude	4347 m	1158 m	620 m

Fig. 5.1

(i) Describe the effect of altitude on the frequency of the haemoglobin alleles in these populations of deer mice.

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(ii) The partial pressure of oxygen is relatively low at high altitudes. Haemoglobin containing glycine at position 64 in the α-polypeptide chain has a higher affinity for oxygen than haemoglobin with aspartic acid at this position.

Suggest how natural selection could account for the difference in allele frequency in deer mice living at high altitudes and low altitudes.

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[Total: 8]

Q24.

2 Myostatin is a protein that is produced in mammalian skeletal muscle cells. It circulates in the blood and acts on muscle tissue to slow down further differentiation and growth.

In thoroughbred racehorses, a mutation involving the substitution of a single nucleotide has been identified in the *MSTN* gene which codes for myostatin. At the site of this mutation, the DNA nucleotide has either a cytosine (C) base or a thymine (T) base, giving race horses three possible genotypes for this mutation: CC, CT or TT.

(a) At two years of age, racehorses with the *MSTN* CC genotype have greater muscle mass than those with the TT genotype.

Suggest an explanation for this difference.

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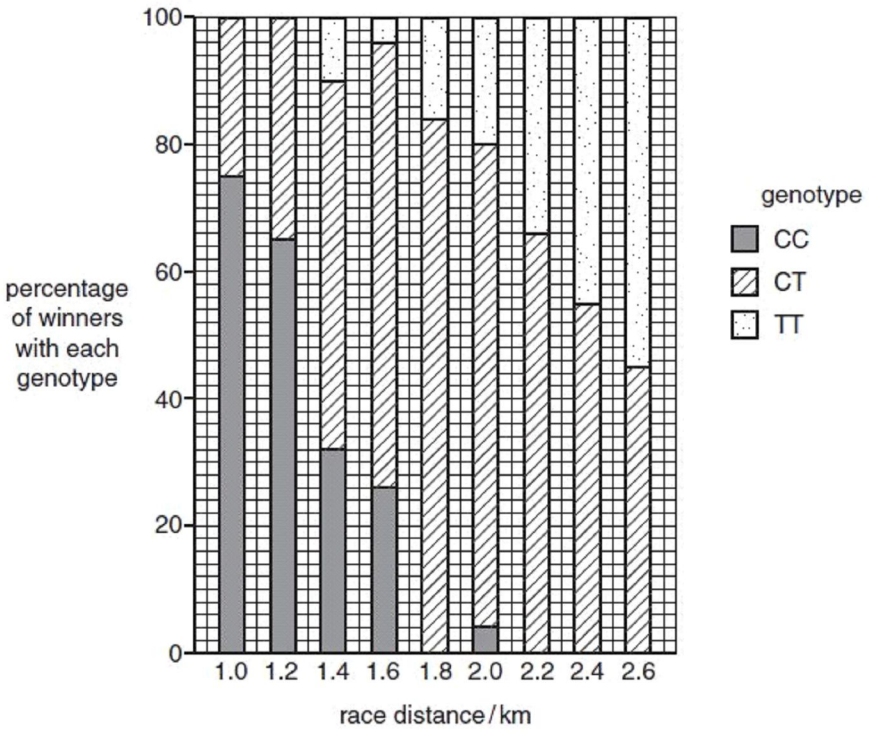
(b) Racehorses that had won races of different distances were tested to determine their *MSTN* genotype.

The results are shown in Fig. 2.1.



With reference to Fig. 2.1, describe the effect of the *MSTN* genotype on the ability of racehorses to win races of different lengths.

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(c) Modern thoroughbred racehorses are the result of many years of artificial selection.

Explain:

(i) what is meant by *artificial selection*

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(ii) how genetic tests for the *MSTN* genotype can help in the selective breeding of racehorses.

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[Total: 10]

Q25.

4 Collared lizards, *Crotaphytus collaris*, show variation in body length and running speed. Fig. 4.1 shows a collared lizard.

Fig. 4.1

An investigation was carried out to find out whether body length and running speed affected the number of offspring that a male lizard sired (fathered). The lizards reproduce sexually, and females lay eggs after mating with males.

A large number of male lizards was captured during the breeding season.

For each lizard:

- body length was measured
- it was chased down a small race track and its fastest running speed over 1 m recorded
- a blood sample was taken and DNA sequences at 10 different loci were analysed.

The lizards were then released back into the place where they were captured, to allow mating to occur.

Several weeks later, after the lizards' eggs had hatched, as many young hatchlings as possible were captured. DNA testing was carried out on each hatchling to determine which male was the father. The results were used to determine the number of offspring sired by each of the male lizards in the first sample.

(a) Outline how DNA analysis can be carried out and then used to establish which male lizard sired each hatchling.

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(b) Fig. 4.2 shows the number of offspring sired plotted against the body length of the adult male lizards.

Fig. 4.3 shows the number of offspring sired plotted against the fastest running speed (sprint speed) of the adult male lizards.

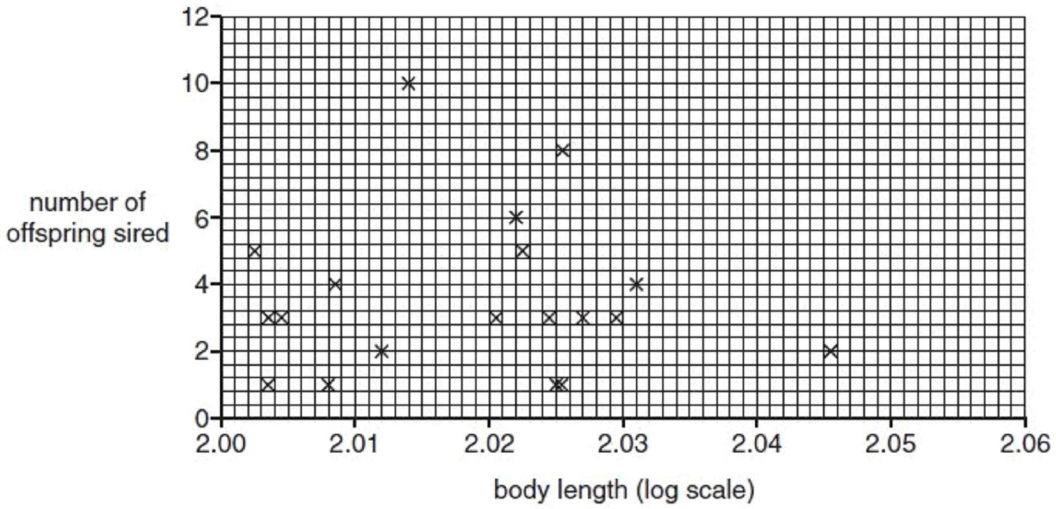

Fig. 4.2

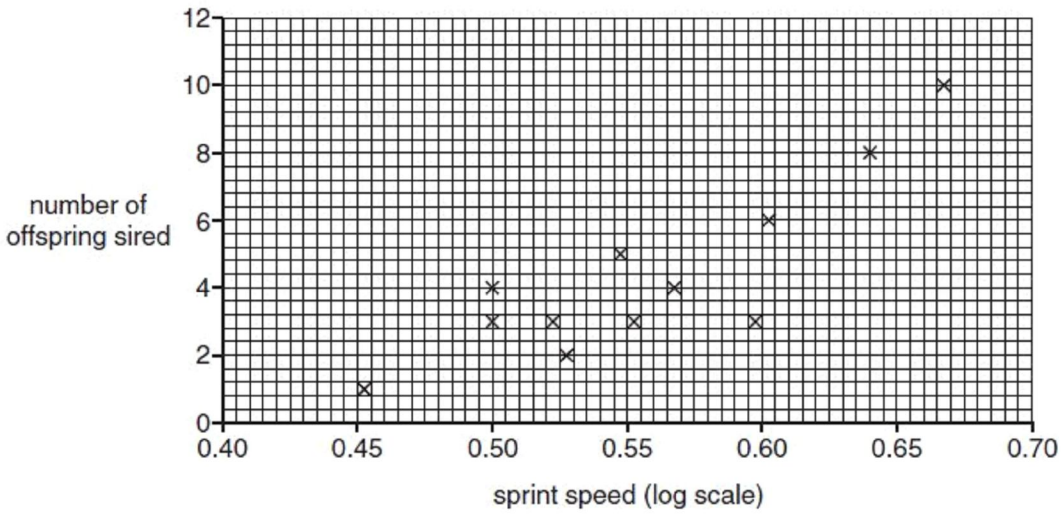

Fig. 4.3

(i) With reference to Fig. 4.2 and Fig. 4.3, describe the relationships between
- body length and the number of offspring produced
- sprint speed and the number of offspring produced.

body length .....

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sprint speed .....

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(ii) Research has also shown that, in a population of collared lizards with varying leg lengths, those with longer hind legs are able to run faster.

With reference to the results shown in Fig. 4.3, explain how, over time, this could lead to a change in the mean hind leg length in a population of collared lizards.

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(c) Small islands often contain species of lizards that are not found on other islands or on the mainland.

Explain how a population of collared lizards that became isolated on an island could evolve to form a new species.

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[Total: 15]

Q26.

1 (a) All modern breeds of dog belong to the same species and are thought to have originated from 14 ancient breeds by the process of artificial selection. The golden retriever is a modern breed that is often used as a guide dog for people who are blind or visually impaired.

Fig. 1.1 shows a golden retriever.

Fig. 1.1

Explain how the principles of artificial selection would have been used to produce golden retrievers with the characteristics required for a guide dog.

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(b) The domestic dog, *Canis familiaris*, is found worldwide. It is able to breed with all other members of the genus to form fertile hybrids.

The distribution of some of the species belonging to the genus *Canis* is shown in Fig. 1.2.

The dingo and the grey wolf species have distinct ranges but the ranges of three species of jackal overlap in East Africa.

Fig. 1.2

Table 1.1

key: ✓ = able to interbreed ✗ = unable to interbreed ? = interbreeding unknown

	dingo	grey wolf	golden jackal	side-striped jackal	black-backed jackal	domestic dog
dingo	✓	?	?	?	?	✓
grey wolf	?	✓	?	?	?	✓
golden jackal	?	?	✓	✗	✗	✓
side-striped jackal	?	?	✗	✓	✗	✓
black-backed jackal	?	?	✗	✗	✓	✓
domestic dog	✓	✓	✓	✓	✓	✓

(i) Suggest the type of isolating mechanism **preventing**:

- the three species of jackal interbreeding

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- the dingo mating with all the other members of the genus *Canis* apart from the domestic dog.

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(ii) Using the information in Fig. 1.2 and Table 1.1, state:

- **one** reason why the members of the genus *Canis* could be described as one species

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- **one** reason why they should be described as separate species.

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[Total: 8]

Q27.

1 Phenylketonuria (PKU) is a genetic disease which results in a raised concentration of the amino acid phenylalanine in the blood. If left untreated in a newborn baby, it can lead to brain damage. For this reason, babies may be tested for PKU soon after birth.

(a) (i) In people without PKU, excess phenylalanine is converted to the amino acid tyrosine by the enzyme phenylalanine hydroxylase (PAH). One of the mutations that can lead to PKU is caused by a base substitution in the gene coding for PAH. This results in the replacement of the amino acid arginine by the amino acid glutamine.

Table 1.1 shows the triplet base codes for arginine and glutamine.

Table 1.1

amino acid	DNA triplet
arginine	GCA
	GCG
	GCT
	GCC
	TCT
	TCC
glutamine	GTT
	GTC

Using the information in Table 1.1, explain how a single base substitution can replace arginine with glutamine in PAH.

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(ii) Suggest the consequence to the structure of PAH as a result of a single base substitution in its gene.

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(b) For some genetic diseases, the proportion of individuals that have the disease can vary in different parts of the world. Sometimes this is due to different environmental conditions. The number of cases of PKU is approximately ten times higher in Europe than in Sub-Saharan Africa.

- Individuals who are carriers of the recessive allele for PKU are more resistant to ochratoxin A, produced by a fungus found on contaminated grain products.
- Ochratoxin A has been linked to a form of renal cancer.
- The fungi that produce ochratoxin A are less common in dry regions such as Sub-Saharan Africa.

Suggest **and** explain the mechanism which has resulted in the different number of cases of PKU in European and Sub-Saharan populations.

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Q28.

2 **(a)** A selective breeding programme to produce a new variety of rice was begun in 1997 in Vietnam. The programme was based on a disease and pest-resistant variety (IR 59655) from the international rice seed bank in the Philippines.

Explain the importance of maintaining an international seed bank.

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(b) The new hybrid variety, VND 404, was ready for trial planting on 6000 hectares in 2002. The differences between VND 404 and its parent variety, IR 59655, are summarised in Table 2.1.

Table 2.1

parent variety IR 59655	new variety VND 404
shorter	taller
longer life cycle	shorter life cycle
smaller yield	greater yield
not able to grow in soil rich in aluminium	able to grow in soil rich in aluminium
less able to compete well with weeds	more able to compete well with weeds

With reference to Table 2.1, explain how the new variety of rice was produced within five years.

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[Total : 8]