CAMBRIDGE INTERNATIONAL AS & A LEVEL BIOLOGY · 9700

BIOLOGY



EXAM QUESTION PACK

17 SELECTION AND EVOLUTION

SCORE	PERCENTAGE
/	%

STEMUP

These questions belong to CIE, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Cambridge International (CIE). They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with CIE and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. CIE has not endorsed, approved or been involved in the production of it. CIE and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

CIE publishes its past papers, mark schemes and examiner reports. Always check the current syllabus at cambridgeinternational.org before you revise.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Chapter 15

Selection and evolution

15.1 Natural and artificial selection

1615. 9700_w15_qp_12 Q: 38

Which group could be a population?

A all the animals and plants on an isolated island

B all the birds counted in one day in a garden

C all the bacteria in a colony of *Bacillus subtilis*

D all the insects occupying three hectares of farmland

1616. 9700_w15_qp_13 Q: 38

What name is given to all the organisms of the same species living in an area?

A community

B ecosystem

C niche

D population

STEMUP.CO.UK

Chapter 13

Selection and evolution

STEMUP.CO.UK

13.1 Natural and artificial selection

243. 9700_s16_qp_22 Q: 3

Globally, measles is an important disease that mainly affects children. Many deaths from measles occur in children under five years of age.

Table 3.1 shows the population of six countries in Africa in 2009 and the number of cases of measles per 100 000 people for the four years 2009 to 2012.
All six countries are classified as low-income countries.

Table 3.1

country	population in 2009	number of cases per 100 000 people			
		2009	2010	2011	2012
Central African Republic	4 266 000	0.26	0.05	15.31	3.12
Chad	11 371 000	1.45	1.66	71.60	0.96
Eritrea	5 558 000	1.48	0.89	0.81	3.16
Ethiopia	84 838 000	1.39	4.86	3.64	4.74
Gambia	1 628 000	0.00	0.12	0.00	0.00
Niger	15 303 000	5.23	2.34	4.67	1.59

(a) (i) The actual number of cases of measles in Chad in 2009 was 165 and in Eritrea was 82.

Calculate the actual number of cases of measles in Ethiopia in 2009.
Show your working.

[2]

(ii) Use the data for Chad, Eritrea and Ethopia to explain the advantages of showing the data in Table 3.1 as number of cases of measles per 100 000 people rather than the actual number of cases.

.....

.....

.....

.....

.....

.....

.....

.....

.....[3]

Fig. 3.1 shows the percentage of children vaccinated against measles over a ten year period from 2003 to 2012.

- The percentage vaccinated represents children under one year of age who have been given at least one dose of the vaccine against measles in the given year.
- The data are for the six African countries shown in Table 3.1.

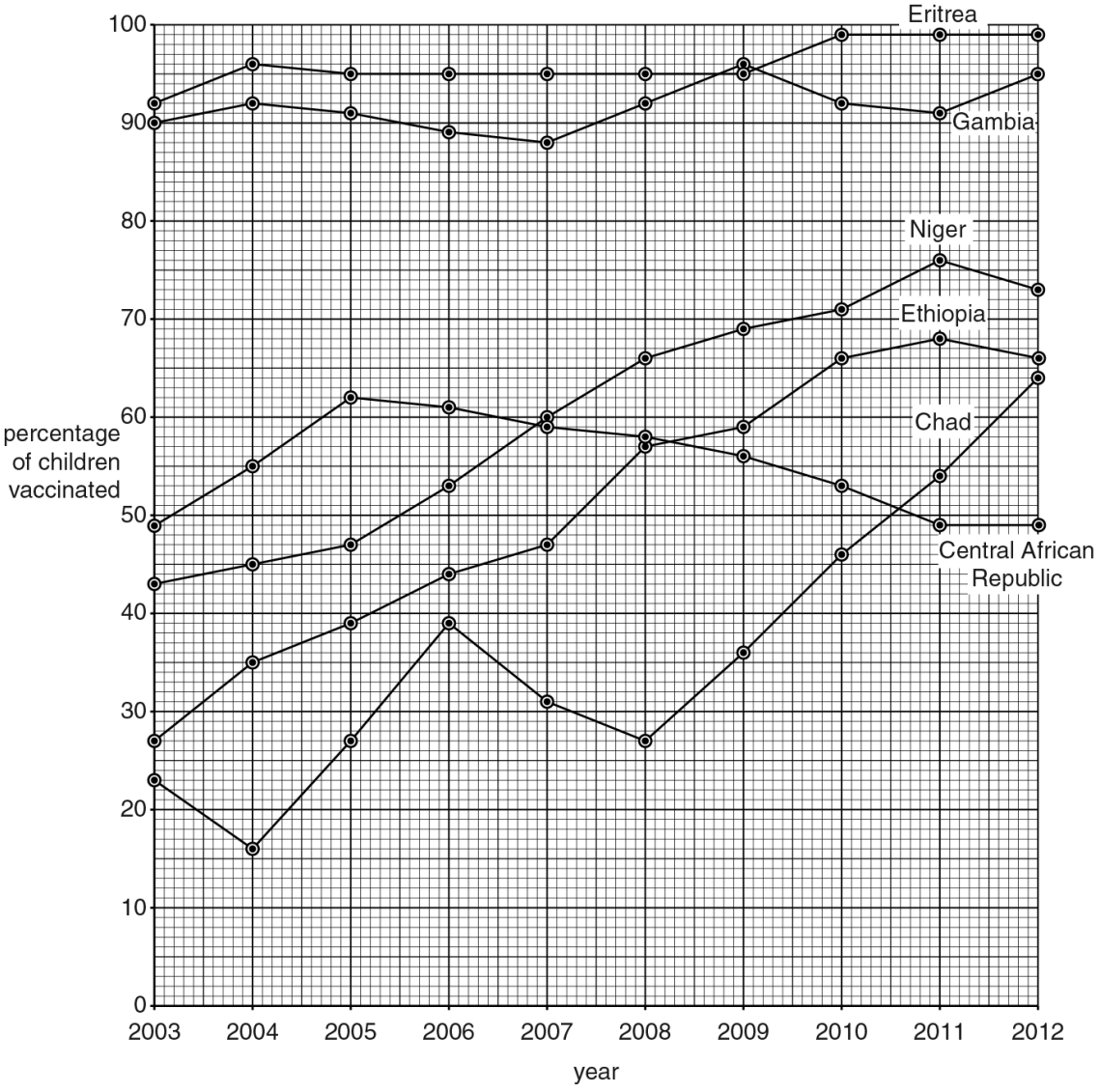


Fig. 3.1

(b) Vaccination is known to protect populations against infectious diseases.

Some of the data in Table 3.1 (on page 4) and Fig. 3.1 (on page 6) support this statement.

Describe the data that support this statement **and** comment on the data that do **not** support this statement.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

(c) The successful eradication of smallpox involved an intensive global vaccination programme. It is hoped that the same can be achieved with measles.

Outline **two** features, apart from cost, of the smallpox eradication programme that may have made it easier to eradicate than measles.

.....

.....

.....

.....

.....

.....[2]

(d) State precisely the type of immunity gained by receiving a measles vaccine.

.....[1]

(e) Planning the prevention and control of measles using a vaccination programme means that financial costs must be considered.

State two examples of these costs.

1 .....

.....

.....

2 .....

.....

.....[2]

[Total: 14]

Q1.

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

.....

.....

.....

.....

.....

.....[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.

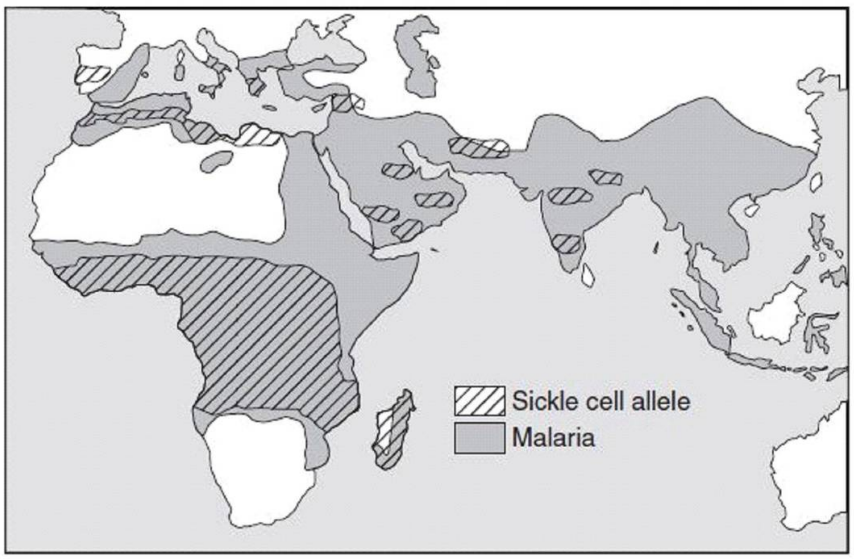


Fig. 4.1

STEMUP.CO.UK

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

.....

.....

.....

.....

.....

.....[4]

[Total: 8]

Q2.

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

.....

.....

.....

.....

.....

.....

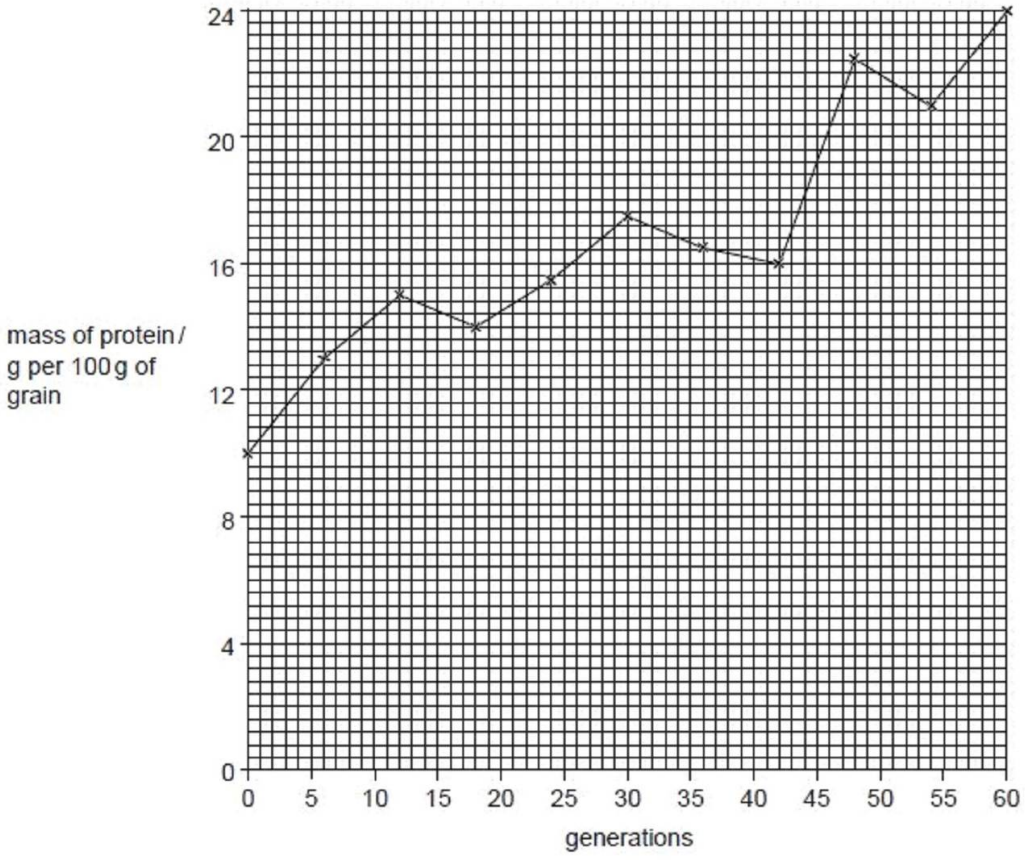
.....

.....[4]

STEMUP.CO.UK

(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.



STEMUP.CO.UK

(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.

.....

.....

.....

.....[2]

[Total: 8]

Q3.

STEMUP.CO.UK

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*.

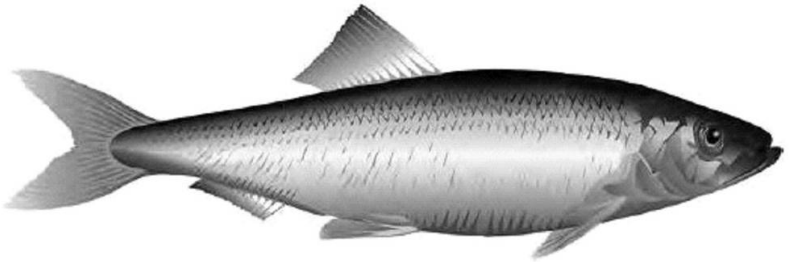


Fig. 8.1

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**.

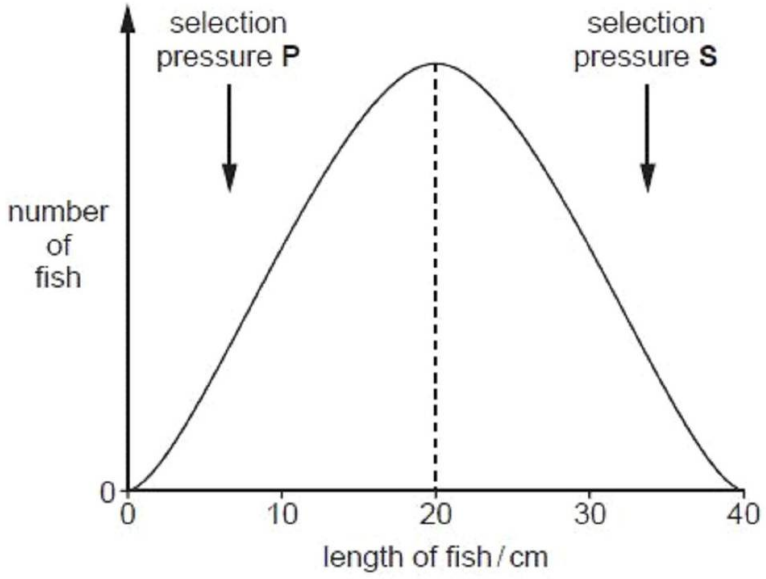
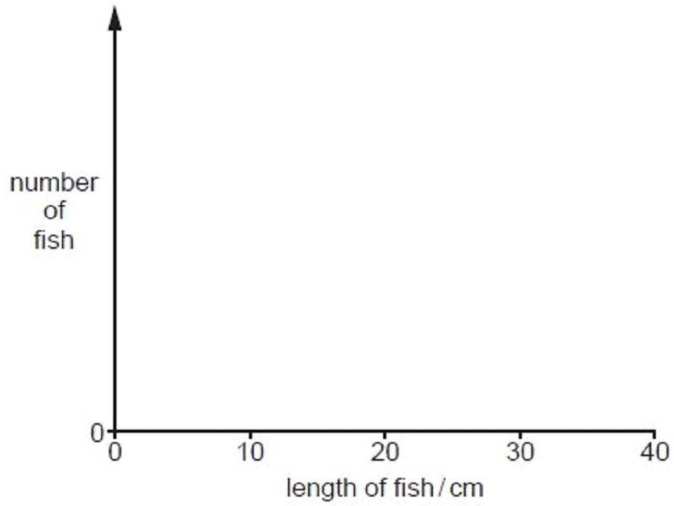


Fig. 8.2

STEMUP.CO.UK

(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.

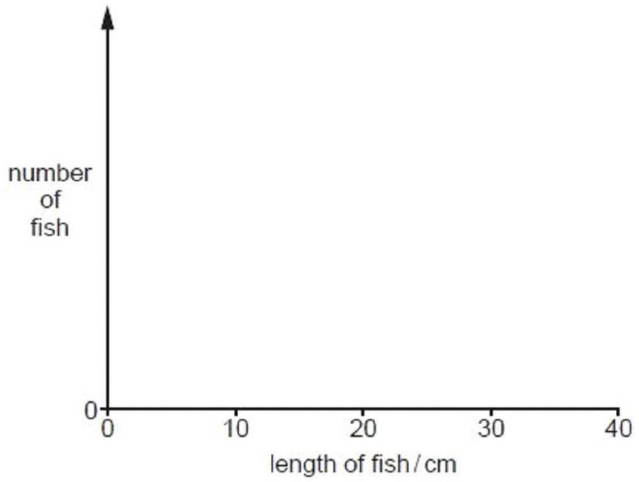


[2]

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

STEMUP.CO.UK

(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.

STEMUP.CO.UK

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. Ex

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

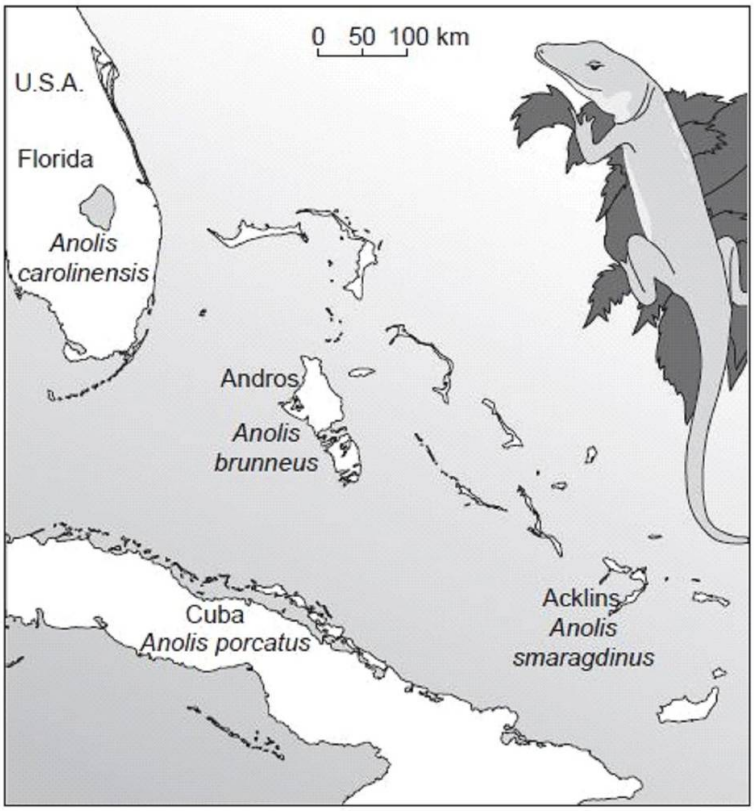


Fig. 5.1

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.

STEMUP.CO.UK

	A. brunneus			
A. brunneus		***A. smaragdinus***		
A. smaragdinus	12.1		***A. carolinensis***	
A. carolinensis	16.7	15.0		***A. porcatus***
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.

.....

.....

.....

.....

.....

..... [3]

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

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 8]

STEMUP.CO.UK

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.

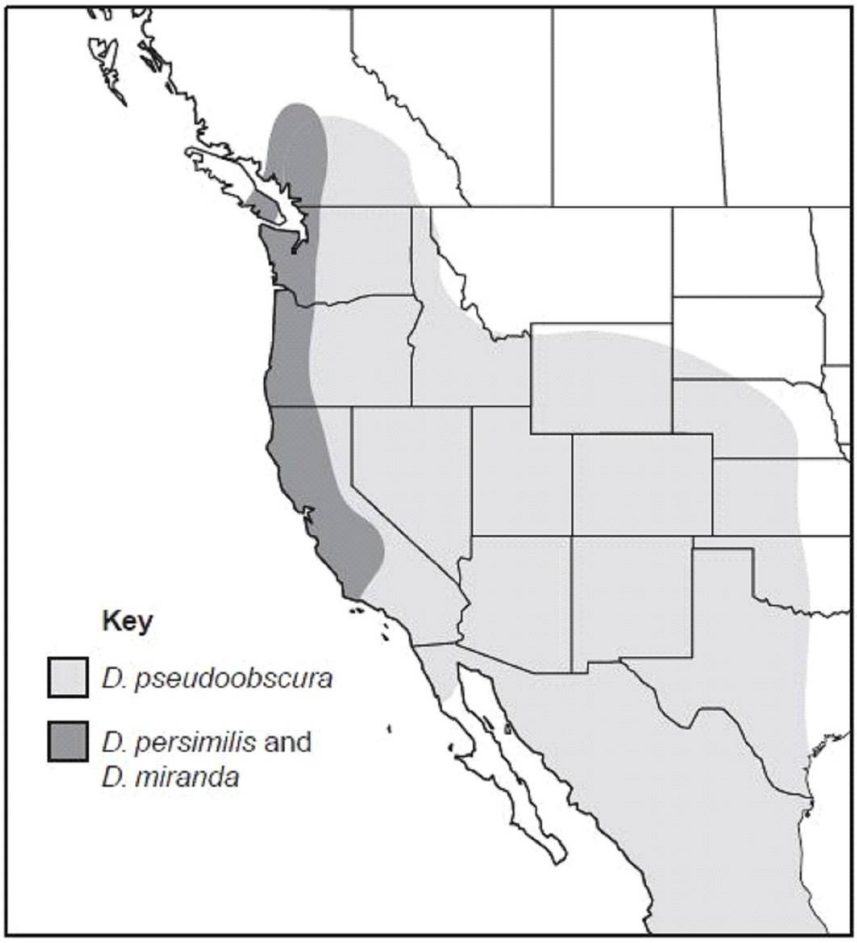


Fig. 5.1

STEMUP.CO.UK

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*.

.....

.....

.....

..... [2]

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

.....

.....

.....

..... [2]

STEMUP.CO.UK

(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*.

.....

.....

.....

.....

.....

.....

.....

..... [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.

STEMUP.CO.UK

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

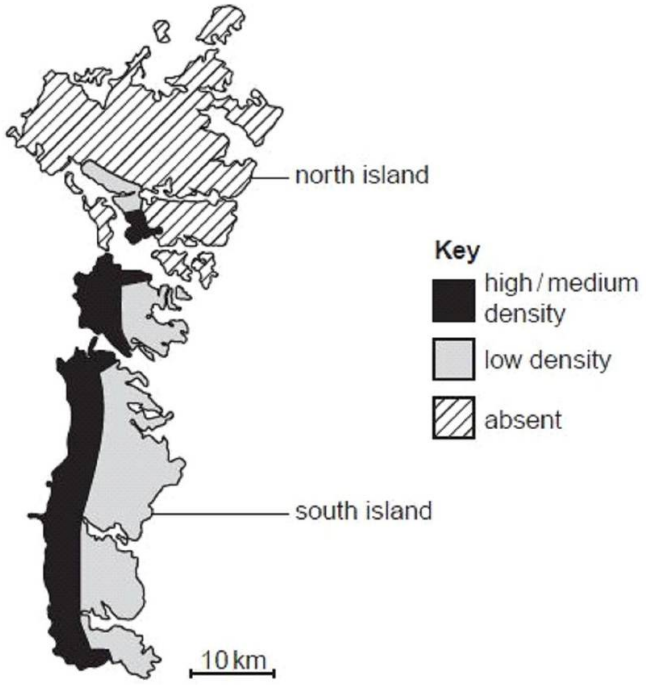


Fig. 8.2

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

STEMUP.CO.UK

(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**.

.....

.....

.....

.....

.....

.....

.....

..... [3]

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

.....

.....

.....

..... [2]

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

F
Exam
U

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 9]

Q7.

STEMUP.CO.UK

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
Us

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

STEMUP.CO.UK

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.

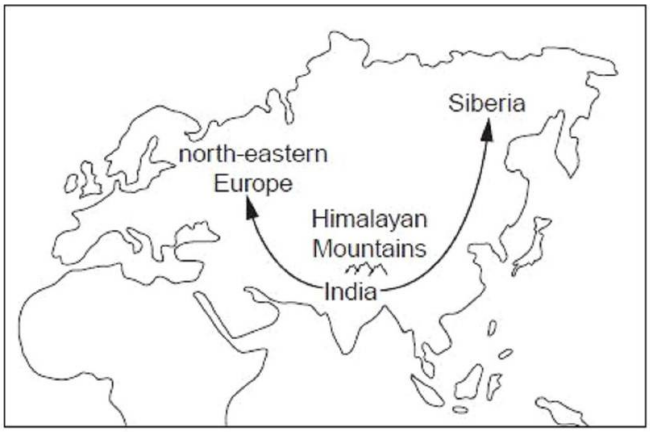


Fig. 1.2

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

.....

.....

.....

.....[2]

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

.....[1]

STEMUP.CO.UK

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[5]

[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.



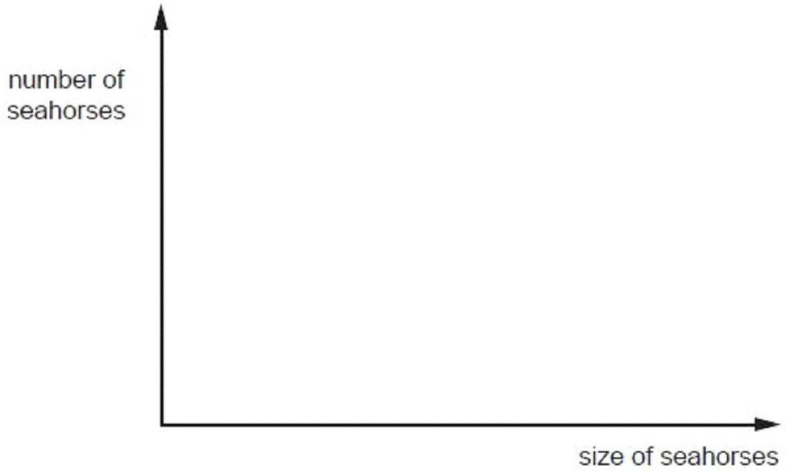
Fig. 1.1

STEMUP.CO.UK

(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.

.....

.....

.....

.....

.....

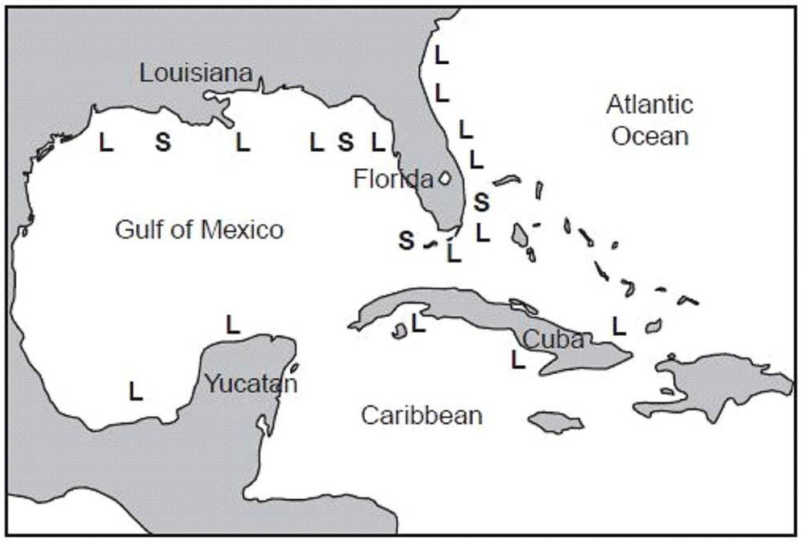
.....[3]

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

.....[1]

STEMUP.CO.UK

(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.

.....

.....

.....

.....

.....

.....

.....[2]

[Total: 8]

Q10.

STEMUP.CO.UK

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]

STEMUP.CO.UK

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

Ex

.....

.....

.....

.....

.....

.....

.....

..... [4]

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

.....

.....

.....

..... [2]

[Total: 8]

Q11.

STEMUP.CO.UK

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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

STEMUP.CO.UK

(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.

.....

.....

.....

..... [2]

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

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

Q12.

STEMUP.CO.UK

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.

.....

.....

.....

.....

.....

.....[4]

(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.

.....

.....

.....

.....[3]

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

.....

.....

.....[2]

[Total : 9]

Q13.

STEMUP.CO.UK

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.

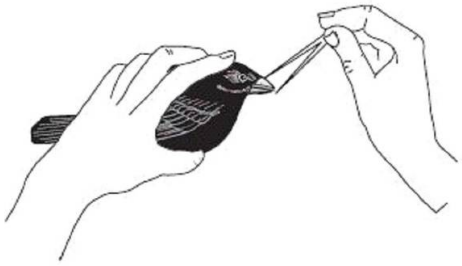


Fig. 4.1

• 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.

STEMUP.CO.UK

(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.

.....

.....

.....

.....

.....[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.

.....

.....

.....

.....

.....[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.

.....

.....

.....[2]

[Total : 8]

Q14.

STEMUP.CO.UK

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.

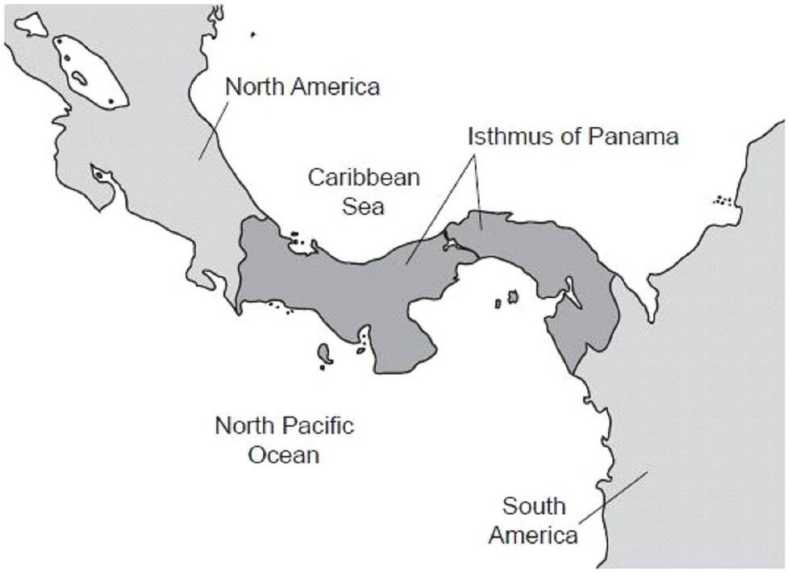


Fig. 4.1

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

.....

.....

.....

..... [2]

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

Isolating mechanism .....

Type of speciation ..... [2]

STEMUP.CO.UK

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 8]

Q15.

STEMUP.CO.UK

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.

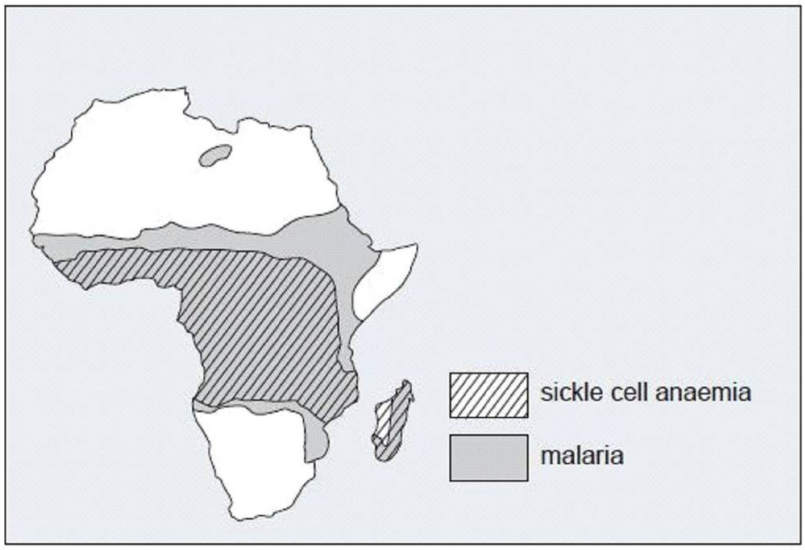


Fig. 9.1

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

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

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

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[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.

.....

.....

.....

.....

.....

.....

.....

.....

.....[5]

STEMUP.CO.UK

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

Explain why variation is important in natural selection.

.....

.....

.....[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.

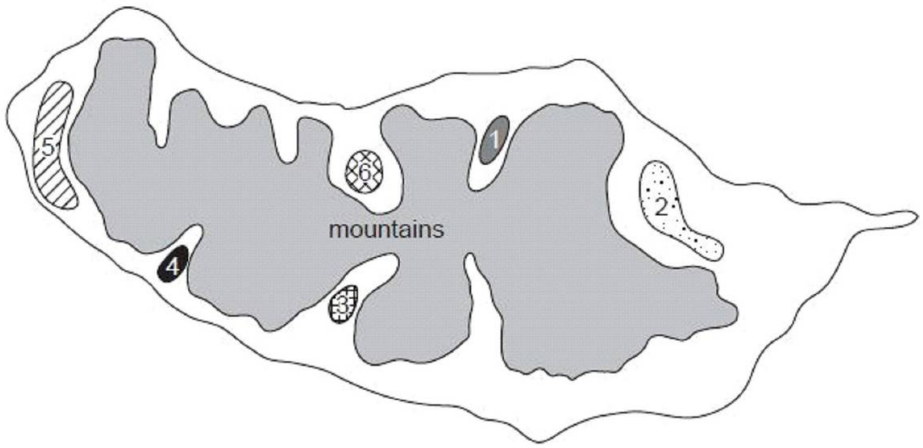


Fig. 2.1

STEMUP.CO.UK

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.

.....

.....

.....

.....

.....

.....

.....

.....

.....[5]

[Total: 7]

Q18.

STEMUP.CO.UK

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.

Exa

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.

.....

.....

.....

.....

.....

..... [3]

STEMUP.CO.UK

(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.

.....

.....

.....

.....[2]

STEMUP.CO.UK

(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.

.....

.....

.....

.....

.....

.....

.....[3]

[Total: 6]

Q20.

STEMUP.CO.UK

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.

STEMUP.CO.UK

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[5]

(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.

.....

.....

.....

.....

.....

.....[3]

STEMUP.CO.UK

(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.

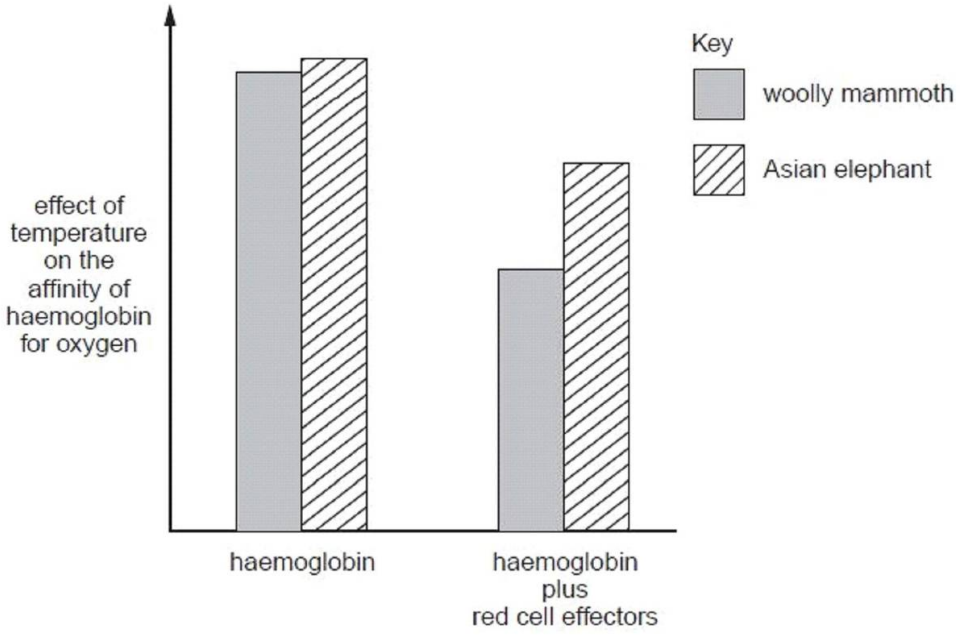


Fig. 2.1

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

.....

.....

.....

.....[2]

STEMUP.CO.UK

(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*

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

[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.

STEMUP.CO.UK

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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

STEMUP.CO.UK

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

.....

.....

.....

.....

.....

.....[2]

(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

.....

.....

.....

.....

.....

.....[3]

(ii) as an evolutionary force in natural selection.

.....

.....

.....

.....

.....

.....[3]

STEMUP.CO.UK

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

Exa

.....

.....

.....

.....

.....

.....[3]

[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.

.....

.....

.....

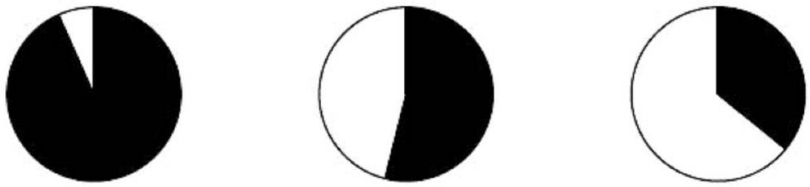
.....

.....

.....[2]

STEMUP.CO.UK

(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.

.....

.....

.....

.....

.....

.....[2]

STEMUP.CO.UK

(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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

[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.

.....

.....

.....

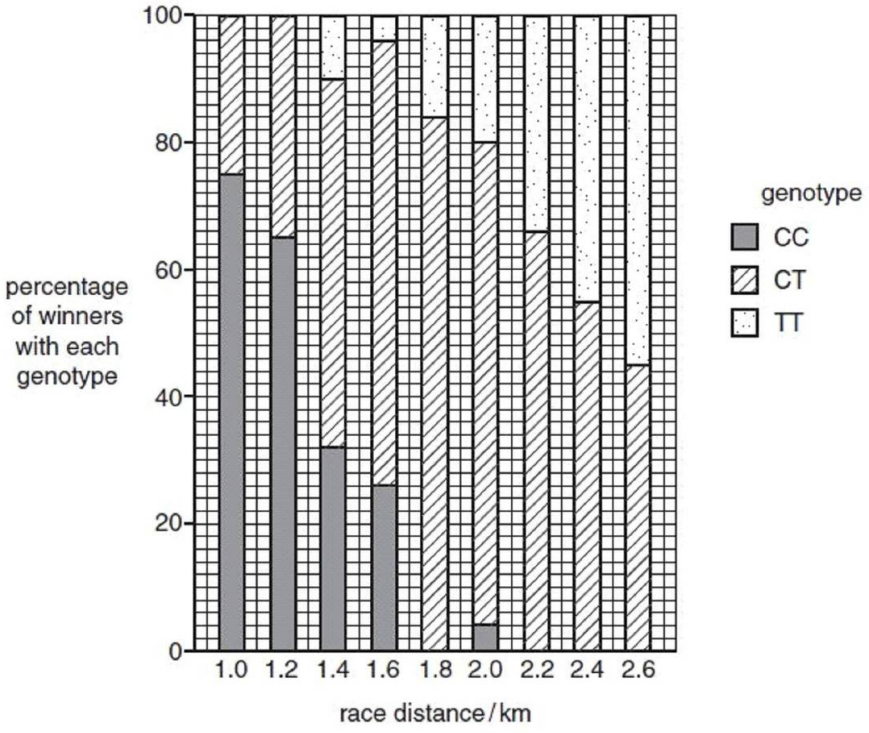
.....

.....[2]

STEMUP.CO.UK

(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.

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

STEMUP.CO.UK

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

Explain:

(i) what is meant by *artificial selection*

.....

.....

.....

.....

.....[2]

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

.....

.....

.....

.....

.....[2]

[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

STEMUP.CO.UK

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.

.....

.....

.....

.....

.....

.....

.....[3]

STEMUP.CO.UK

(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.

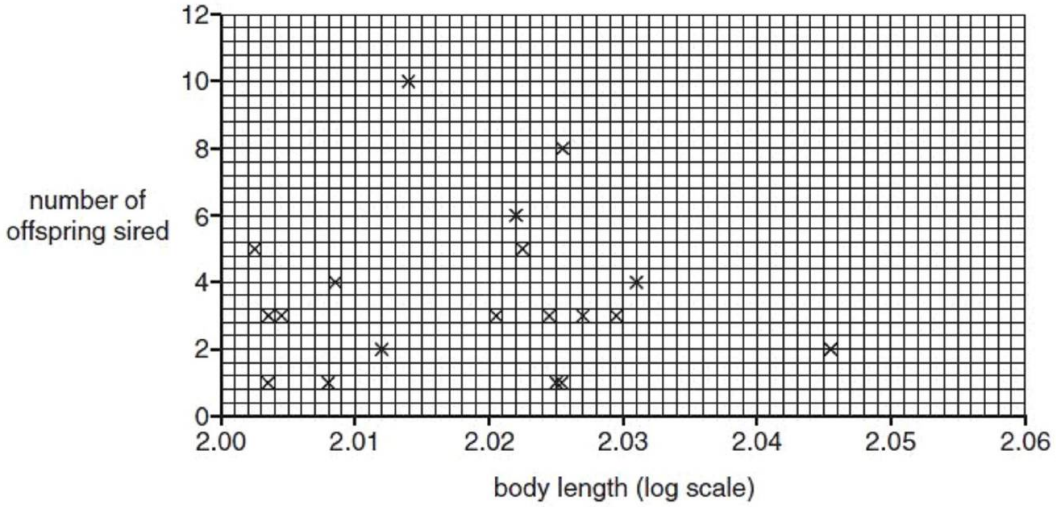


Fig. 4.2

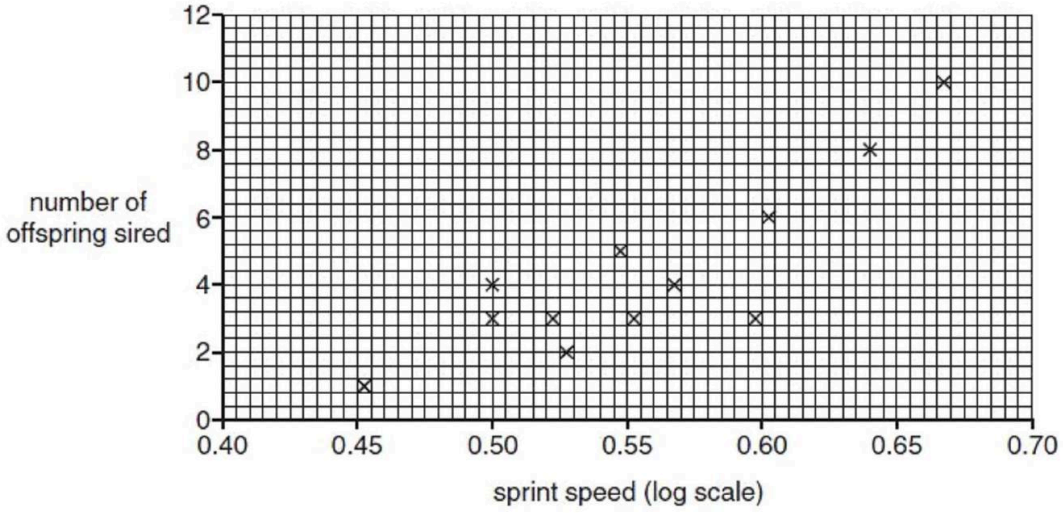


Fig. 4.3

STEMUP.CO.UK

(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 .....

.....

.....

.....

.....

sprint speed .....

.....

.....

.....

.....[4]

(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.

.....

.....

.....

.....

.....

.....

.....

.....

.....[3]

STEMUP.CO.UK

(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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[5]

[Total: 15]

Q26.

STEMUP.CO.UK

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.

.....

.....

.....

.....

.....

.....

.....

.....[4]

STEMUP.CO.UK

(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.

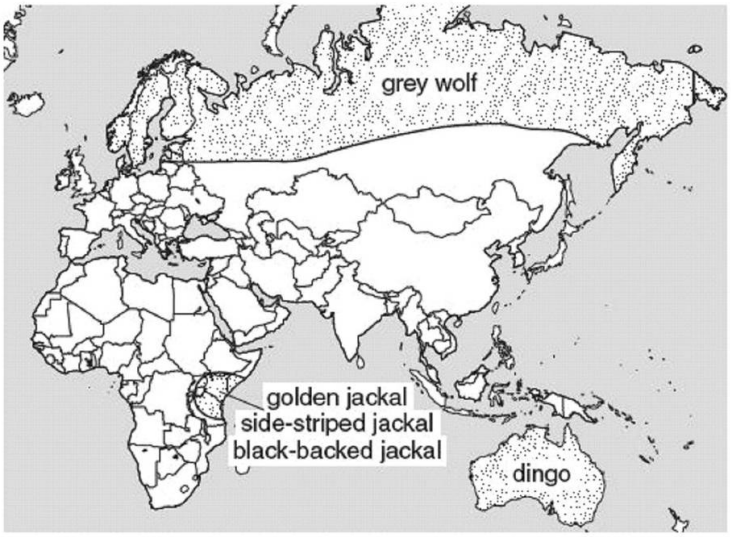


Fig. 1.2

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	✓	✓	✓	✓	✓	✓

STEMUP.CO.UK

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

- the three species of jackal interbreeding

.....

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

.....[2]

(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

.....

.....

.....

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

.....

.....

.....[2]

[Total: 8]

Q27.

STEMUP.CO.UK

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.

.....

.....

.....

.....

.....

.....[2]

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

.....

.....

.....[1]

STEMUP.CO.UK

(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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[5]

Q28.

STEMUP.CO.UK

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.

.....

.....

.....

.....

.....

.....[4]

(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

STEMUP.CO.UK

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

.....

.....

.....

.....

.....

.....[4]

[Total : 8]

STEMUP.CO.UK

1. Nov/2018/Paper_41/No.3

(a) Meiosis is one process that contributes to genetic variation.

(i) State **precisely** the stage of meiosis where single chromosomes line up on the equator.

..... [1]

(ii) Outline the events taking place during anaphase I of meiosis.

.....

.....

.....

.....

.....

..... [2]

(iii) Describe how crossing over during meiosis leads to genetic variation.

.....

.....

.....

.....

..... [2]

Mutation also causes genetic variation. Some populations of water hemp, *Amaranthus tuberculatus*, have evolved herbicide resistance as a result of a mutation. This is a problem for farmers as water hemp grows in crop fields, lowering productivity.

Two populations of water hemp were tested for resistance to the herbicide mesotrione. One was a population known to be resistant (control) and the other was a test population, whose resistance was unknown.

- Leaves were removed and immersed in a radioactively labelled solution of mesotrione.
- The leaves absorbed some mesotrione and became radioactive.
- Resistant leaves are able to degrade mesotrione by metabolism.
- The time for 50% of absorbed mesotrione to degrade was calculated by measuring the radioactivity of the leaves.

The results are shown in Table 3.1.

Table 3.1

population of water hemp	mean time for 50% of absorbed mesotrione to degrade / hours	standard deviation
test	27.5	4.75
control	10.1	2.34

(b) (i) Explain how the results in Table 3.1 show that the two populations differ in their resistance to mesotrione.

.....

.....

.....

.....

..... [2]

(ii) Explain why this example of genetic variation is important for natural selection in water hemp populations.

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

(iii) Farmers can send in a sample of leaves of water hemp from their fields to a laboratory to be tested for resistance to mesotrione or other herbicides.

Suggest the benefit of this to a farmer.

.....

.....

.....

..... [1]

(c) The null hypothesis states there is no significant difference between the mean times for 50% of absorbed mesotrione to degrade in the two populations.

A *t*-test can be carried out to compare these two means. The critical value for *t* at the $p = 0.05$ significance level is 2.23.

(i) Use the formula in Fig. 3.1 to calculate the value of *t*.

Show your working.

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

Key
$\bar{x}$ = mean
s = standard deviation
n_1 = 6 (number of readings for test population)
n_2 = 6 (number of readings for control population)

Fig. 3.1

t = ... [2]

(ii) Use your calculated value of *t* to explain whether the null hypothesis should be accepted or rejected.

accept or reject .....

explanation .....

.....

.....

.....[2]

[Total: 14]

STEMUP.CO.UK

2. Nov/2018/Paper_41/No.4

The Hawaiian archipelago is a group of volcanic islands in the Pacific ocean.

Fig. 4.1 shows the relative locations of five of these islands.



Fig. 4.1

Table 4.1 shows the size and age of these five islands and the total number of *Mecyclothorax* ground beetle species and their species density, on each island.

Data for the island of Maui is shown as two distinct regions, West and Haleakalā. This is because they formed at different times from two separate volcanoes.

Table 4.1

island	area / km^2	age of island / million years	total number of *Mecyclothorax* species	species density / number of species per km^2
Hawai'i	10433	0.4	30	0.003
Lāna'i	364	1.3	3	0.008
Maui (West)	443	1.3	27	0.061
Maui (Haleakalā)	1440	1.1	116	0.081
Moloka'i	673	1.9 – 1.8	43	0.064
O'ahu	1545	3.7 – 2.6	20	.....

STEMUP.CO.UK

Fig. 4.2 shows a ground beetle of the genus *Mecyclothorax*. All the beetle species of this genus on the Hawaiian archipelago form a monophyletic group, descended from one original colonising species that reached Maui from Australia.

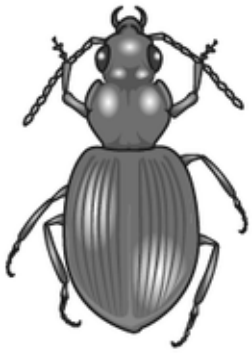


Fig. 4.2

(a) (i) Complete Table 4.1 by calculating the density of *Mecyclothorax* beetle species on the island of O'ahu. [1]

(ii) Use Table 4.1 to explain why the island of Hawai'i has the lowest density of *Mecyclothorax* beetle species.

.....

.....

.....

.....

.....

..... [2]

(iii) Use Fig. 4.1 and Table 4.1 to suggest why O'ahu has a lower number of *Mecyclothorax* beetle species than Moloka'i.

.....

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

(b) The rate of speciation of *Mecyclothorax* beetles on the slopes of the volcano Haleakalā, on Maui, is the highest recorded for any genus or location on earth.

The volcano last erupted 400 years ago. This produced lava flows which cut through ancient forest and vegetation, dividing it into many separate microhabitats.

Explain how the large number of *Mecyclothorax* beetle species on Haleakalā developed.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

[Total: 9]

STEMUP.CO.UK

3. Nov/2018/Paper_43/No.3

(a) Meiosis is one process that contributes to genetic variation.

(i) State **precisely** the stage of meiosis where single chromosomes line up on the equator.

..... [1]

(ii) Outline the events taking place during anaphase I of meiosis.

.....

.....

.....

.....

.....

..... [2]

(iii) Describe how crossing over during meiosis leads to genetic variation.

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

Mutation also causes genetic variation. Some populations of water hemp, *Amaranthus tuberculatus*, have evolved herbicide resistance as a result of a mutation. This is a problem for farmers as water hemp grows in crop fields, lowering productivity.

Two populations of water hemp were tested for resistance to the herbicide mesotrione. One was a population known to be resistant (control) and the other was a test population, whose resistance was unknown.

- Leaves were removed and immersed in a radioactively labelled solution of mesotrione.
- The leaves absorbed some mesotrione and became radioactive.
- Resistant leaves are able to degrade mesotrione by metabolism.
- The time for 50% of absorbed mesotrione to degrade was calculated by measuring the radioactivity of the leaves.

The results are shown in Table 3.1.

Table 3.1

population of water hemp	mean time for 50% of absorbed mesotrione to degrade / hours	standard deviation
test	27.5	4.75
control	10.1	2.34

(b) (i) Explain how the results in Table 3.1 show that the two populations differ in their resistance to mesotrione.

.....

.....

.....

.....

..... [2]

(ii) Explain why this example of genetic variation is important for natural selection in water hemp populations.

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

(iii) Farmers can send in a sample of leaves of water hemp from their fields to a laboratory to be tested for resistance to mesotrione or other herbicides.

Suggest the benefit of this to a farmer.

.....

.....

.....

..... [1]

(c) The null hypothesis states there is no significant difference between the mean times for 50% of absorbed mesotrione to degrade in the two populations.

A *t*-test can be carried out to compare these two means. The critical value for *t* at the $p = 0.05$ significance level is 2.23.

(i) Use the formula in Fig. 3.1 to calculate the value of *t*.

Show your working.

$$t = \frac{|\bar{x}_1 - \bar{x}_2|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

Key
$\bar{x}$ = mean
s = standard deviation
n_1 = 6 (number of readings for test population)
n_2 = 6 (number of readings for control population)

Fig. 3.1

t = ... [2]

(ii) Use your calculated value of *t* to explain whether the null hypothesis should be accepted or rejected.

accept or reject .....

explanation .....

.....

.....

.....[2]

[Total: 14]

STEMUP.CO.UK

4. Nov/2018/Paper_43/No.4

The Hawaiian archipelago is a group of volcanic islands in the Pacific ocean.

Fig. 4.1 shows the relative locations of five of these islands.



Fig. 4.1

Table 4.1 shows the size and age of these five islands and the total number of *Mecyclothorax* ground beetle species and their species density, on each island.

Data for the island of Maui is shown as two distinct regions, West and Haleakalā. This is because they formed at different times from two separate volcanoes.

Table 4.1

STEMUP.CO.UK

Fig. 4.2 shows a ground beetle of the genus *Mecyclothorax*. All the beetle species of this genus on the Hawaiian archipelago form a monophyletic group, descended from one original colonising species that reached Maui from Australia.

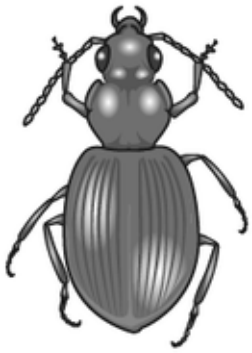


Fig. 4.2

(a) (i) Complete Table 4.1 by calculating the density of *Mecyclothorax* beetle species on the island of O'ahu. [1]

(ii) Use Table 4.1 to explain why the island of Hawai'i has the lowest density of *Mecyclothorax* beetle species.

.....

.....

.....

.....

.....

..... [2]

(iii) Use Fig. 4.1 and Table 4.1 to suggest why O'ahu has a lower number of *Mecyclothorax* beetle species than Moloka'i.

.....

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

(b) The rate of speciation of *Mecyclothorax* beetles on the slopes of the volcano Haleakalā, on Maui, is the highest recorded for any genus or location on earth.

The volcano last erupted 400 years ago. This produced lava flows which cut through ancient forest and vegetation, dividing it into many separate microhabitats.

Explain how the large number of *Mecyclothorax* beetle species on Haleakalā developed.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

[Total: 9]

STEMUP.CO.UK

1. Nov/2019/Paper_41/No.2

The stickleback fish, *Gasterosteus aculeatus*, has two distinct forms, the saltwater form and the freshwater form. The larger, freshwater form is thought to have evolved from the smaller, saltwater form. Both forms have armour plating on each side of the body. The plates are made of bone and contain a high proportion of calcium.

The ectodysplasin gene, *EDA*, codes for a protein involved in the development of armour plates. The *EDA* gene has two alleles, low armour and high armour.

Three main morphs of armour plating have been described.

Complete morph armour plating:

- is found mainly in the saltwater form
- has many plates from head to tail to cover most of the body
- provides defence against large, predatory fish
- limits the growth of the fish.

Partial morph armour plating:

- is found mainly in the freshwater form
- has a reduced number of plates to cover only part of the body.

Low morph armour plating:

- is found mainly in the freshwater form
- has very few, undeveloped plates and no body cover.

(a) Explain why the variation in armour plating in stickleback fish can be described as discontinuous.

.....

.....

.....

..... [2]

(b) In 1982, at Loberg Lake in Southern Alaska, the entire freshwater stickleback fish population was accidentally destroyed by humans.

In 1990, a new population of stickleback fish was found in the lake. Most of these fish had armour plates from head to tail on each side.

Suggest why these new stickleback fish have armour plates from head to tail on each side, despite living in freshwater.

.....

.....

..... [1]

(c) From 1990, annual sampling took place in the lake.

Each year showed a reduction in the number of individuals with complete morph armour plating (from head to tail on each side). This change took place in a relatively short period of time.

- In 1990, 96% of the stickleback fish population had complete morph armour plating.
- In 1993, 39% of the stickleback fish population had complete morph armour plating.

Explain how natural selection has occurred in this new stickleback fish population.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 8]

STEMUP.CO.UK

2. Nov/2019/Paper_41/No.6

The genus *Heliconius* contains more than 40 species of brightly patterned butterflies.

Researchers have investigated in the laboratory how one species, *Heliconius heurippa*, could have developed as a separate species. The phenotype of *H. heurippa* is intermediate between that of two other species, *H. cydno* and *H. melpomene*.

Laboratory breeding experiments showed that:

- matings between *H. cydno* and *H. melpomene* (parent species) produce fertile hybrid offspring
- controlled matings of the hybrids produces individuals identical in appearance to *H. heurippa* within three generations
- hybrid butterflies prefer to mate with each other, rather than with individuals of either of the parent species.

The researchers concluded that the *H. heurippa* species could contain DNA from the two parent species as a result of hybridisation.

(a) (i) Suggest, with reasons, **one** prediction that can be made about the chromosome numbers of *H. cydno* and *H. melpomene*.

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

(ii) The researchers thought that, because the hybrid butterflies preferred to mate with each other, this could make speciation more likely to occur.

Give reasons why the researchers thought that this made speciation more likely.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

STEMUP.CO.UK

(b) *Heliconius* butterflies taste unpleasant to predators such as birds. The bright colours on the wings of the butterflies act as warnings so that birds avoid eating them.

Individual birds have to learn which patterns to avoid. If one *Heliconius* species is abundant, or if it has a pattern shared with another similar species, predators learn to avoid this pattern faster. Therefore this pattern provides a selective advantage.

In the wild, *Heliconius* hybrids occur in small numbers and have patterns that do not resemble the established warning pattern of either parent species. These hybrids have a selective disadvantage.

This is an example of a post-zygotic isolating mechanism.

Explain how selection against hybrids can act as a post-zygotic isolating mechanism.

.....

.....

.....

.....

.....

..... [2]

[Total: 8]

STEMUP.CO.UK

3. Nov/2019/Paper_42/No.2

The stickleback fish, *Gasterosteus aculeatus*, has two distinct forms, the saltwater form and the freshwater form. The larger, freshwater form is thought to have evolved from the smaller, saltwater form. Both forms have armour plating on each side of the body. The plates are made of bone and contain a high proportion of calcium.

The ectodysplasin gene, *EDA*, codes for a protein involved in the development of armour plates. The *EDA* gene has two alleles, low armour and high armour.

Three main morphs of armour plating have been described.

Complete morph armour plating:

- is found mainly in the saltwater form
- has many plates from head to tail to cover most of the body
- provides defence against large, predatory fish
- limits the growth of the fish.

Partial morph armour plating:

- is found mainly in the freshwater form
- has a reduced number of plates to cover only part of the body.

Low morph armour plating:

- is found mainly in the freshwater form
- has very few, undeveloped plates and no body cover.

(a) Explain why the variation in armour plating in stickleback fish can be described as discontinuous.

.....

.....

.....

..... [2]

STEMUP.CO.UK

(c) From 1990, annual sampling took place in the lake.

Each year showed a reduction in the number of individuals with complete morph armour plating (from head to tail on each side). This change took place in a relatively short period of time.

- In 1990, 96% of the stickleback fish population had complete morph armour plating.
- In 1993, 39% of the stickleback fish population had complete morph armour plating.

Explain how natural selection has occurred in this new stickleback fish population.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 8]

STEMUP.CO.UK

4. Nov/2019/Paper_42/No.6

The genus *Heliconius* contains more than 40 species of brightly patterned butterflies.

Researchers have investigated in the laboratory how one species, *Heliconius heurippa*, could have developed as a separate species. The phenotype of *H. heurippa* is intermediate between that of two other species, *H. cydno* and *H. melpomene*.

Laboratory breeding experiments showed that:

- matings between *H. cydno* and *H. melpomene* (parent species) produce fertile hybrid offspring
- controlled matings of the hybrids produces individuals identical in appearance to *H. heurippa* within three generations
- hybrid butterflies prefer to mate with each other, rather than with individuals of either of the parent species.

The researchers concluded that the *H. heurippa* species could contain DNA from the two parent species as a result of hybridisation.

(a) (i) Suggest, with reasons, **one** prediction that can be made about the chromosome numbers of *H. cydno* and *H. melpomene*.

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

(ii) The researchers thought that, because the hybrid butterflies preferred to mate with each other, this could make speciation more likely to occur.

Give reasons why the researchers thought that this made speciation more likely.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

STEMUP.CO.UK

(b) *Heliconius* butterflies taste unpleasant to predators such as birds. The bright colours on the wings of the butterflies act as warnings so that birds avoid eating them.

Individual birds have to learn which patterns to avoid. If one *Heliconius* species is abundant, or if it has a pattern shared with another similar species, predators learn to avoid this pattern faster. Therefore this pattern provides a selective advantage.

In the wild, *Heliconius* hybrids occur in small numbers and have patterns that do not resemble the established warning pattern of either parent species. These hybrids have a selective disadvantage.

This is an example of a post-zygotic isolating mechanism.

Explain how selection against hybrids can act as a post-zygotic isolating mechanism.

.....

.....

.....

.....

.....

..... [2]

[Total: 8]

STEMUP.CO.UK

5. Nov/2019/Paper_43/No.4

A 28-year study of Magellanic penguins, *Spheniscus magellanicus*, found in Argentina, provides evidence of natural selection.
Magellanic penguins lay their eggs in nests. They use their bills (beaks) to catch prey and feed their chicks (offspring) in the nest. Each breeding pair of penguins uses the same nest each year.

A Magellanic penguin is shown in Fig. 4.1.



Fig. 4.1

- Data were collected for bill size every year from 1983 to 2010.
- Bill size was calculated using the length and depth of the bill.
- Bill size showed variation between the individuals.
- In 1983 all the penguins in one area were tagged.
- All tagged penguins were measured each year and their new chicks were tagged and measured.
- For each year of the study, an estimate of food availability was made.
- A statistical analysis was conducted to quantify whether selection had taken place.

(a) Explain why bill size is an example of continuous variation.

.....

.....

.....

..... [2]

STEMUP.CO.UK

(b) Statistical analysis of the data showed that selection was **not** significant in most years of the study. However, a significant increase in bill size occurred in four years of the study.

(i) Name the type of selection that occurred in these four years.

..... [1]

(ii) In these same four years, food availability was low.

Explain how the data for bill size and food availability supports the idea of the 'struggle for existence' seen in natural selection.

.....

.....

.....

.....

.....

..... [2]

(c) Further investigation showed that, in some years, larger bill sizes of adult males correlated with higher reproductive success.

Reproductive success was measured by the number of chicks that survived per adult each year.

Suggest why larger bill size of adult males correlated with higher reproductive success.

.....

.....

.....

..... [1]

[Total: 6]

STEMUP.CO.UK

6. Nov/2019/Paper_43/No.5

Mimulus is a plant genus containing a diverse range of species that have colourful flowers to attract pollinators, such as bees and hummingbirds. Pollinators transfer pollen between flowers for plant sexual reproduction.

Table 5.1 compares some features of two closely-related species of *Mimulus* that both grow in the same region of North America.

The features in which they differ are:

- the altitude at which the two species grow
- their flower characteristics, including petal colour and the distance from the opening of the flower to the nectar on which the pollinators feed
- the percentages of pollinator visits that they receive from bees or from hummingbirds.

Table 5.1

STEMUP.CO.UK

species of *Mimulus*	altitude / m	petal colour	distance to nectar / mm	percentage of visits from pollinator type	
				bee	hummingbird
M. lewisii	1600 – 3000	pink	14	100	0
M. cardinalis	0 – 2000	red	27	3	97

(a) With reference to the data in Table 5.1, explain the isolating mechanisms that prevent gene flow between *M. lewisii* and *M. cardinalis* populations.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

STEMUP.CO.UK

(b) Breeding experiments in the laboratory show that *M. lewisii* and *M. cardinalis* can breed together and produce offspring. The F1 hybrid offspring are fertile.

(i) Suggest, with reasons, what prediction can be made about the chromosome numbers of *M. lewisii* and *M. cardinalis*.

.....

.....

.....

.....

.....

..... [2]

(ii) The F1 hybrids produce 50% fewer seeds than either of the two parent species.

Explain how the reduced production of seeds by the inter-species (F1) hybrids can act as a post-zygotic isolating mechanism.

.....

.....

.....

.....

.....

..... [2]

[Total: 9]

STEMUP.CO.UK

7. June/2019/Paper_41/No.3(b, c)

(b) *PINK1* codes for a protein kinase enzyme that is important in the functioning of mitochondria in neurones.

Most recessive *PINK1* mutations are base substitutions which lead to the production of a non-functioning protein kinase enzyme.

Explain how a base substitution mutation can lead to the production of a non-functioning protein kinase.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(c) One rare, dominant mutation of the *PINK1* gene codes for a product that inhibits the normal protein kinase.

Explain how this mutation causes EOPD in a heterozygote.

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

8. June/2019/Paper_41/No.5

Researchers investigated the extent to which the founder effect and natural selection affected evolutionary change.

Fig. 5.1 shows the brown anole lizard, *Anolis sagrei*. These lizards live on a number of Caribbean islands and feed on a variety of invertebrates and other small animals.

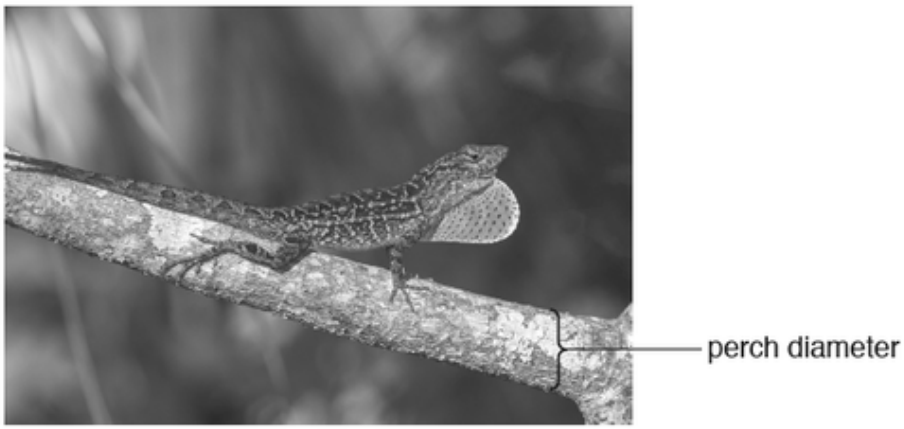


Fig. 5.1

A. sagrei spends a lot of time perching (resting) on, or moving along, branches of shrubs and trees. The width of the branch that *A. sagrei* perches on is known as the perch diameter, as labelled in Fig. 5.1.

There is a positive correlation between perch diameter and hind limb length of *A. sagrei*.

- Longer hind limbs allow *A. sagrei* to run faster on vegetation with a larger diameter.
- Shorter hind limbs are needed to provide stability on vegetation of a smaller diameter.

In 2004, a hurricane caused the death of all the *A. sagrei* lizards on seven islands.

In 2005, the researchers randomly collected seven male and seven female lizards from a source population on a nearby island. For each of the seven islands affected by the hurricane, a male and female lizard were mated and placed on each island. These islands formed the experimental founder islands where new populations of *A. sagrei* were successfully established from each founding pair.

Fig. 5.2 shows the difference in vegetation between the source island and the seven experimental founder islands.



Fig. 5.2

STEMUP.CO.UK

(a) **(i)** Predict the effect of natural selection on mean hind limb length of *A. sagrei* on the seven experimental founder islands.

.....

..... [1]

(ii) Predict how collecting individuals **at random** for the seven founding pairs affects the mean hind limb length of *A. sagrei* on the different islands.

.....

..... [1]

(b) Many generations of *A. sagrei* were produced over the four years after the introduction of the founding pairs.

Fig. 5.3 shows how the mean hind limb length of *A. sagrei* changed on the seven experimental islands and on the source island.

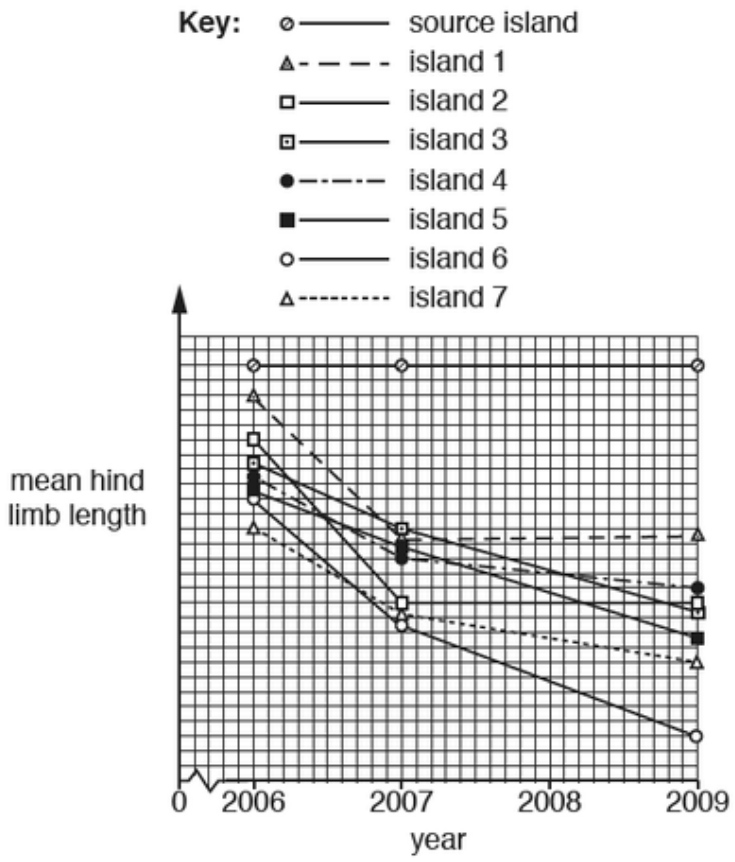


Fig. 5.3

STEMUP.CO.UK

With reference to Fig. 5.2 and Fig. 5.3, describe **and** suggest explanations for the results for the islands.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(c) In the investigation, one population of *A. sagrei* was established on each experimental founder island.

Outline how speciation may occur on the seven experimental founder islands.

.....

.....

.....

.....

.....

..... [3]

STEMUP.CO.UK

(d) Speciation is one possible outcome for the experimental founder populations, but there is also a high risk that they may become extinct.

Explain why the experimental founder populations are at high risk of extinction.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 13]

STEMUP.CO.UK

9. June/2019/Paper_42/No.6

(a) State the general theory of evolution.

.....

.....

..... [1]

(b) Different types of organism have evolved different structures containing light receptors. Eyes are organs containing light receptors.

Fig. 6.1 describes the light receptors of several types of organism.

Euglena (a single-celled eukaryote) has a simple eyespot that can only detect the intensity and direction of light.
Turbellarian flatworms have cup-shaped eyes, each with a layer of light receptor cells. They can detect the intensity and direction of light better than *Euglena*. They also detect movement.
The mollusc *Nautilus* has eyes with deeper cups and narrower openings for light to enter. They can form a rough image, see shapes and detect the direction of light better than turbellarian flatworms.
The mollusc *Nucella* has eyes with lenses made of jelly. They can form a more detailed image than the eyes of *Nautilus* and can focus light to a small degree.
Mammals have eyes that are more complex than *Nucella*. They have a fixed lens (the cornea) that bends light and a lens that can change shape to focus on objects at different distances. The lenses focus light onto a deeply cup-shaped layer of light receptor cells. The eyes form a very detailed image.

Fig. 6.1

STEMUP.CO.UK

Using the information in Fig. 6.1, suggest how a complex eye such as that of mammals could have evolved in successive stages.

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) Octopuses are molluscs that have eyes very similar to those of mammals.

Octopuses and mammals are not closely related.

Octopuses and mammals have lenses that can change shape to focus on objects at different distances.

Suggest reasons why octopuses and mammals have evolved similar eye structures.

.....

.....

.....

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

(d) Molecular evidence is used to investigate evolution. One study involved a marine worm, *Platynereis dumerilii*, that still has characteristics similar to its ancestors from 600 million years ago.

Researchers sequenced all the proteins in light receptor cells of *P. dumerilii* and humans. The results showed that there are many similarities between the protein sequences of *P. dumerilii* and humans, particularly in the light-detecting protein opsin.

(i) State what this molecular evidence indicates about the evolutionary origins of *P. dumerilii* and humans.

.....

..... [1]

(ii) Explain how amino acid sequences indicate how close the relationship is between two species.

.....

.....

.....

.....

..... [2]

[Total: 10]

STEMUP.CO.UK

10. June/2019/Paper_42/No.10(b)

(b) Explain how speciation may occur as a result of geographical separation. [7]

STEMUP.CO.UK

11. June/2019/Paper_43/No.3

The cilia of ciliated epithelial cells show variation in length, within an individual and between different individuals.

Samples of ciliated epithelial tissue were removed from the airways of healthy people and the mean cilia length for each individual was calculated.

The people in the study formed two groups:

- people who were exposed to a harmful environmental factor
- people who were **not** exposed to a harmful environmental factor.

The results are shown in Fig. 3.1.

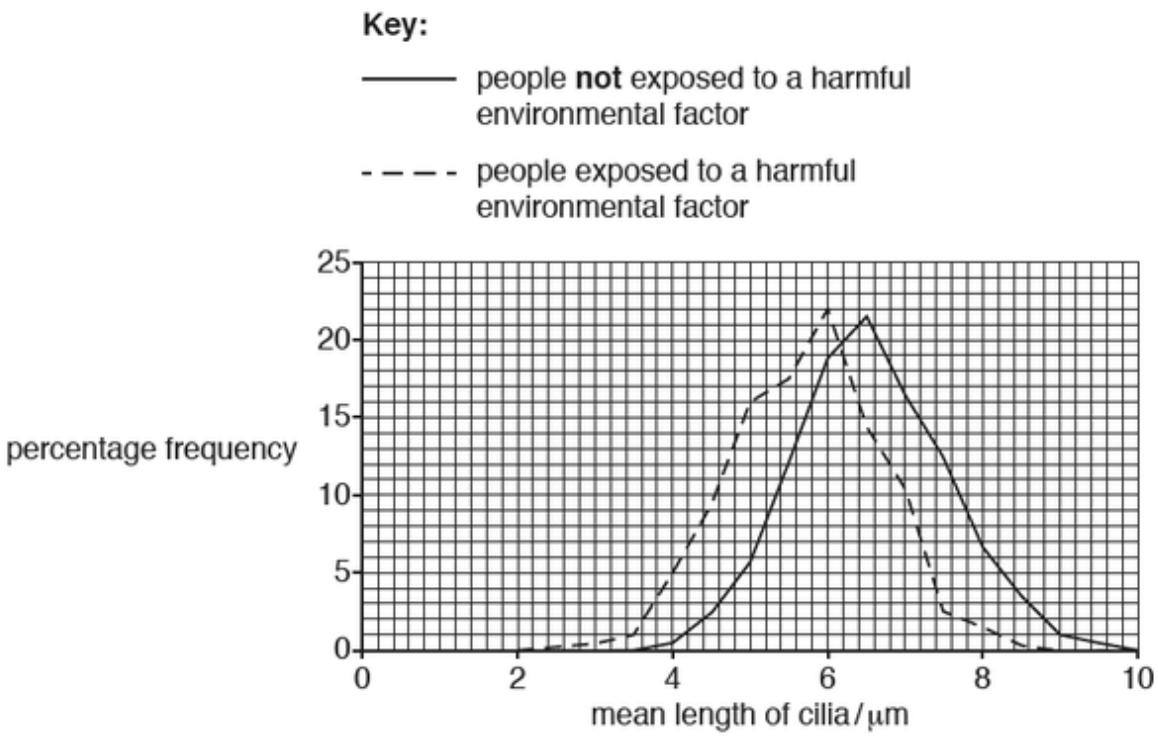


Fig. 3.1

(a) (i) Name the type of variation shown for mean cilia length in each group of people in Fig. 3.1.

..... [1]

(ii) Suggest **two** harmful environmental factors that people might have been exposed to that could explain the difference between the two curves in Fig. 3.1.

.....

.....

..... [2]

STEMUP.CO.UK

(b) The development and final length of cilia of epithelial cells is controlled by many genes.

Fig. 3.2 summarises the interactions of some of these genes. The arrows represent the genes being switched on.

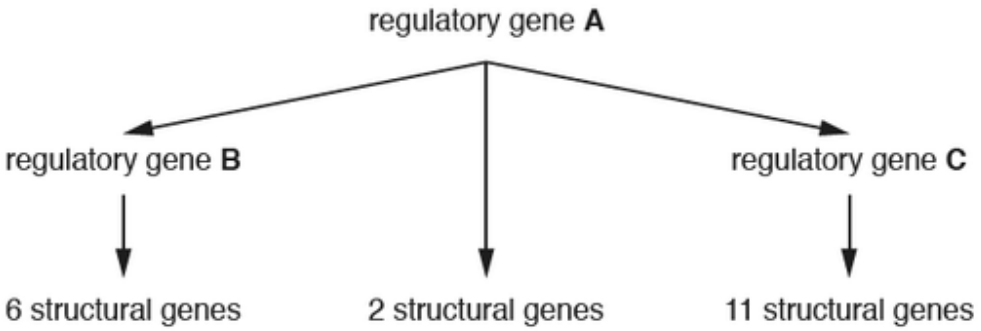


Fig. 3.2

(i) With reference to Fig. 3.2, explain how genes such as **A**, **B** and **C** are able to switch on other genes.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

STEMUP.CO.UK

(ii) Describe how microarray analysis can be used to identify the genes switched on by the product of gene **C**.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(c) Microarray analysis has shown that ciliated epithelial cells and other epithelial cells in the airways express genes that code for receptor proteins on cell surface membranes. These receptor proteins detect specific chemicals.

When the receptor proteins bind to specific chemicals, this causes coughing, constriction of the airways and an increase in cilia activity. In people who have asthma, the response can be severe and life-threatening.

Suggest how knowledge of the genes for these receptor proteins could help in the treatment of asthma.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 15]

STEMUP.CO.UK

12. June/2019/Paper_43/No.6

(a) Regressive evolution is a change in a population over time that involves the **loss** of certain phenotypic characteristics. It is thought to be caused by either genetic drift or natural selection.

An example of regressive evolution is the loss of eyes in one form of the Mexican cavefish, *Astyanax mexicanus*. These eyeless cavefish live in caves that are in total darkness.

There are three theories to explain how the loss of eyes in the cavefish has occurred.

Theory A
There is no advantage to having eyes in a cave that is in total darkness, where energy sources are scarce. Having eyes is a disadvantage as there may be an energy cost.

Theory B
A mutation has occurred in a single gene. This mutation has two effects:

- a lack of eye development
- an increase in the number of chemoreceptors on the skin.

Theory C
Various mutations occurred in the genes responsible for eye development over a period of time. By chance, these mutations increased in frequency in small isolated populations. Eventually this produced a population of eyeless cavefish.

(i) State **one** theory, **A**, **B** or **C**, which describes genetic drift as the cause of loss of eyes.

.....

[1]

(ii) State **and** explain which theory or theories are based on natural selection as the cause of loss of eyes.

.....

.....

.....

.....

.....

.....

..... [4]

STEMUP.CO.UK

(b) There are several separate populations of eyeless *A. mexicanus* in different caves.

There are populations of *A. mexicanus* that spend time in areas with light and the fish in these populations have eyes.

The mitochondrial DNA (mtDNA) of eyeless *A. mexicanus* was compared to the mtDNA of *A. mexicanus* with eyes.

(i) Suggest how DNA evidence can help find out whether the eyeless *A. mexicanus* and the *A. mexicanus* with eyes are the same species or different species.

.....

.....

.....

..... [2]

(ii) Suggest why mtDNA is used instead of nuclear DNA when studying the closeness of the relationship between populations.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

STEMUP.CO.UK

13. Feb/2019/Paper_42/No.3(b, c)

(b) Transcription factors are proteins. Genes that code for proteins can become mutated.

Describe how different types of gene mutation can cause changes in the protein that is synthesised.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

STEMUP.CO.UK

(c) BLIMP-1 is a transcription factor that is essential for the development of plasma cells and memory B-cells in the process shown in Fig. 3.1. BLIMP-1 reduces the synthesis of c-Myc in B-lymphocytes. c-Myc is a protein that is required for the mitotic cell cycle to continue.

Suggest **and** explain how a mutation in the gene coding for BLIMP-1 can prevent the development of plasma cells and memory B-cells.

.....

.....

.....

.....

.....

.....

.....

.....[3]

STEMUP.CO.UK

14. Feb/2019/Paper_42/No.4

Mexican spadefoot toads, *Spea multiplicata*, live on land but return to ponds to breed. Eggs are laid in water and hatch into tadpoles, which feed in ponds before developing into adults.

The tadpoles can be classified into two main types: omnivore-type tadpoles and carnivore-type tadpoles. Differences between the phenotypes of these two types of tadpole are related to their different feeding behaviours.

- Omnivore-type tadpoles feed on tiny pieces of detritus (dead material from plants and animals) and algae (microscopic photosynthetic organisms) at the bottom of ponds. These tadpoles grow slowly.
- Carnivore-type tadpoles feed on small animals in the water, such as fairy shrimp and small omnivore tadpoles. These tadpoles grow quickly.

Fig. 4.1 shows two tadpoles of the same age, one of each type. A fairy shrimp is also shown. All three organisms are at the same distance from the camera.

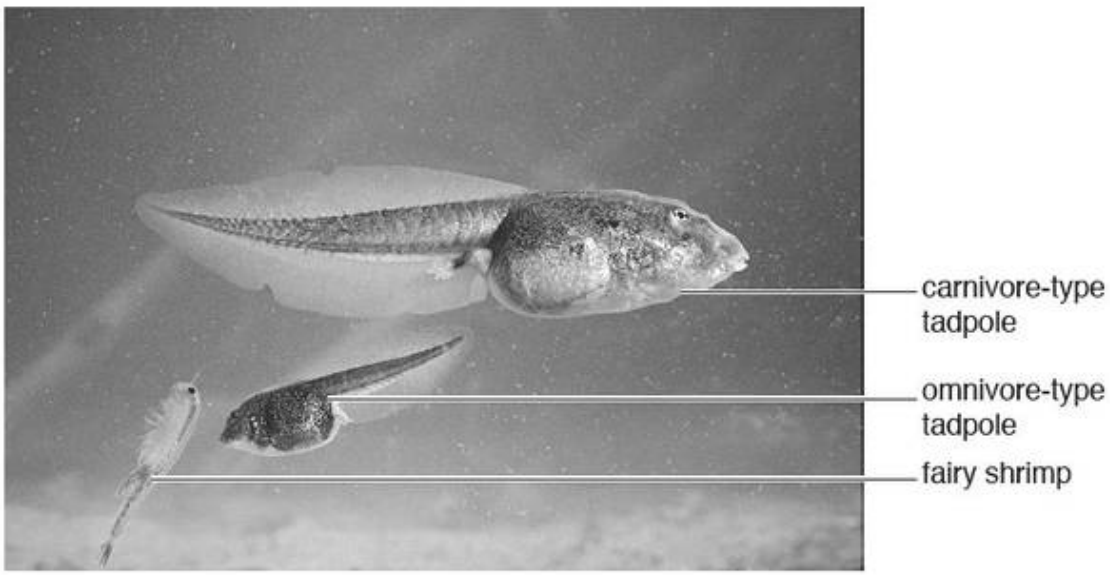


Fig. 4.1

Between these two main types of tadpole there is a continuous range of tadpoles with intermediate body phenotypes and feeding behaviours.

For any individual tadpole, regardless of age, it is possible to calculate a phenotype score depending on the features of the tadpole. A tadpole with a phenotype score close to 3 is a typical omnivore type and a tadpole with a phenotype score close to 7 is a typical carnivore type.

The phenotype scores were determined for a large number of tadpoles sampled from two ponds. The availability of detritus and algae was high for one pond and low for the other pond. All other conditions in the two ponds were similar.

For both ponds, phenotype scores were determined shortly after the tadpoles had hatched from eggs and ten days later.

STEMUP.CO.UK

The results are shown in Fig. 4.2.

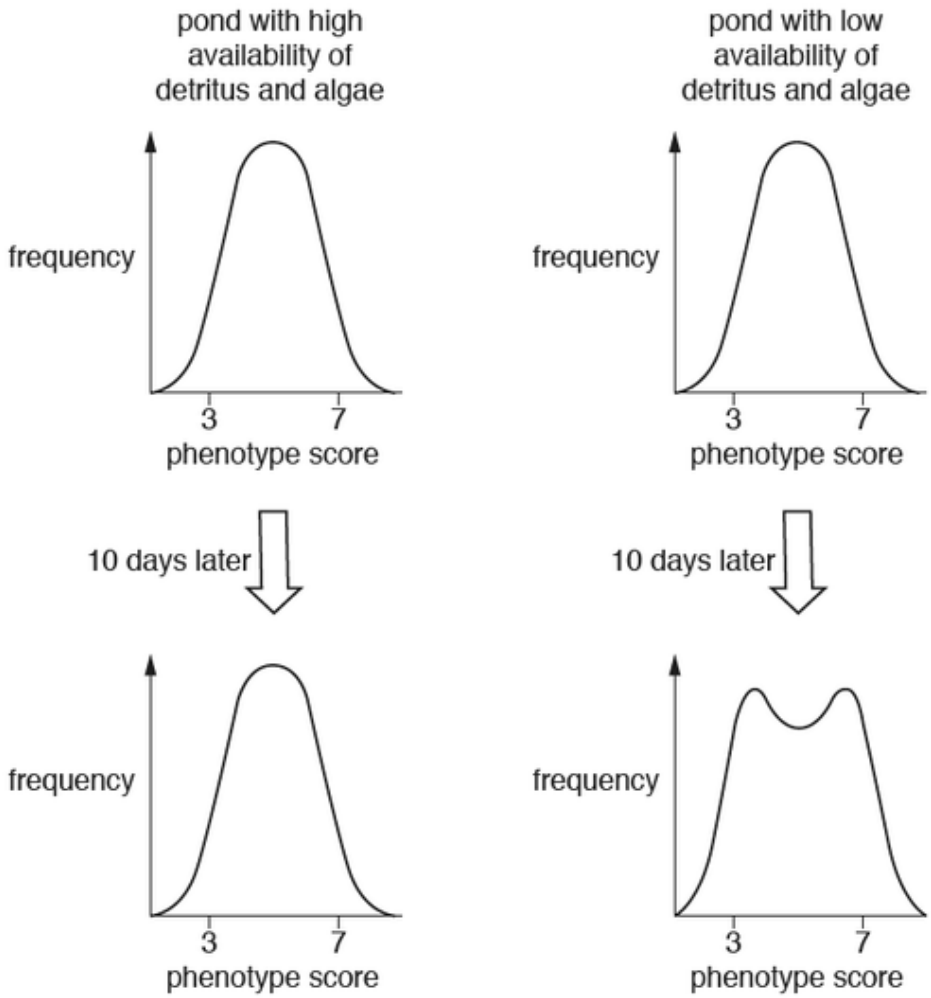


Fig. 4.2

(a) Using the results shown in Fig. 4.2, describe **and** suggest an explanation for the change in frequency of tadpole phenotypes in the pond with **low** availability of detritus and algae.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

STEMUP.CO.UK

(b) Eleven days after eggs had hatched, the mean body masses of omnivore-type tadpoles and carnivore-type tadpoles in the pond with low availability of detritus and algae were measured. The results are shown in Fig. 4.3.

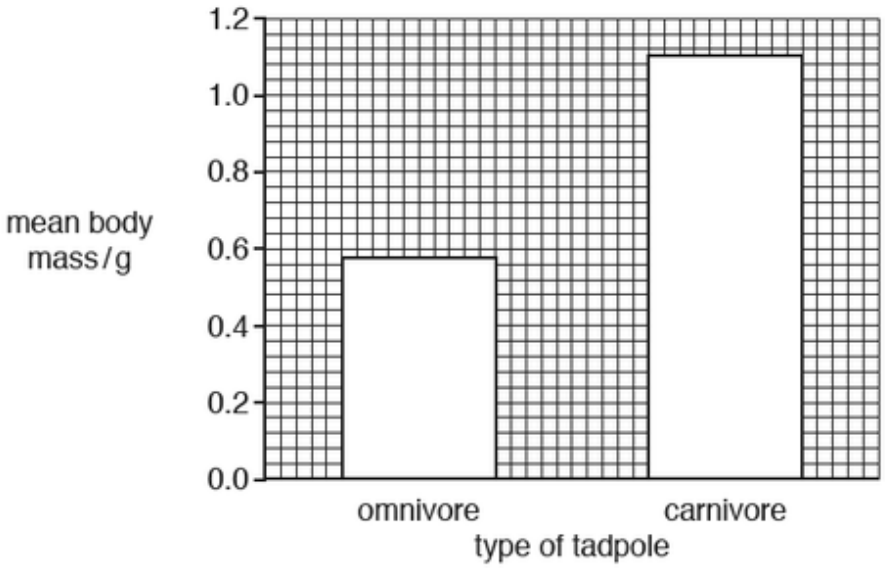


Fig. 4.3

Using the data in Fig. 4.3, calculate the mean body mass of an omnivore-type tadpole as a percentage of the mean body mass of a carnivore-type tadpole.

Show your working.

percentage = ...%

[2]

STEMUP.CO.UK

(c) The phenotype scores of a large number of tadpoles were determined in a different pond with **very low** availability of detritus and algae. All other conditions were the same as the first two ponds. As previously, measurements were taken shortly after the eggs hatched and ten days later. After ten days, nearly all of the Mexican spadefoot toad tadpoles in this pond were carnivore types.

The results are shown in Fig. 4.4.

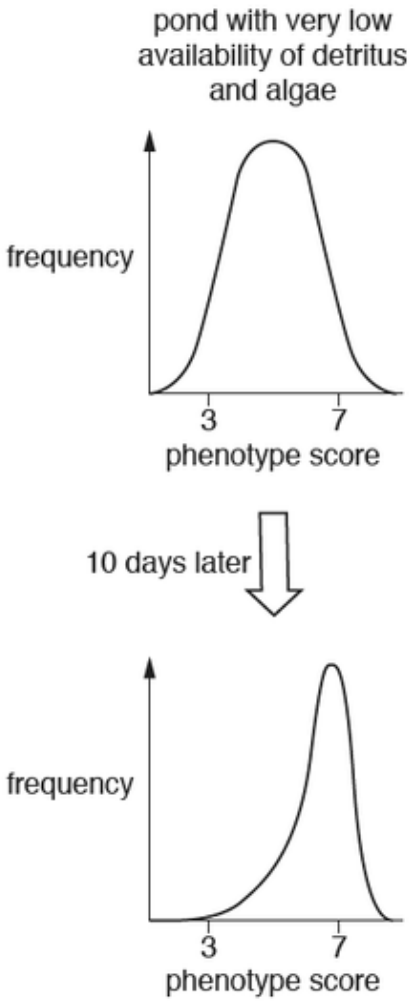


Fig. 4.4

(i) State the type of natural selection that is acting on the tadpoles in the pond with **very low** availability of detritus and algae.

..... [1]

(ii) Suggest explanations for the change in phenotype frequencies of the tadpoles in the pond with **very low** availability of detritus and algae, as shown in Fig. 4.4.

.....

.....

.....

..... [2]

STEMUP.CO.UK

(d) Mexican spadefoot toad tadpoles develop into adult toads that do not live in water.

In some years, the ponds where Mexican spadefoot toad tadpoles live, dry out quickly.

Suggest why the carnivore-type tadpoles have a selective advantage in the years when ponds dry out quickly.

.....

.....

..... [1]

[Total: 10]

15. Feb/2019/Paper_42/No.6(b)

(b) Analysis of mtDNA can show how recently species have evolved from each other.

Describe the properties of mtDNA that make it suitable for the study of evolution.

.....

.....

.....

.....

.....

.....

.....

..... [3]

STEMUP.CO.UK

16. Feb/2019/Paper_42/No.10(a)

(a) State the general theory of evolution and explain the process of natural selection in evolution. [7]

STEMUP.CO.UK

1. Nov/2021/Paper_41/No.8

California salamanders are terrestrial amphibians.

An original population of California salamanders occupied an area of forest in northern California. Approximately 10 million years ago, two separate populations, **A** and **B**, started to migrate from the original population.

- Population **A** travelled along the coast of California, to the west of the Great Central Valley.
- Population **B** travelled east of the Great Central Valley.

The two populations now live close to each other in southern California.

Fig. 8.1 outlines the migratory routes of populations **A** and **B**.

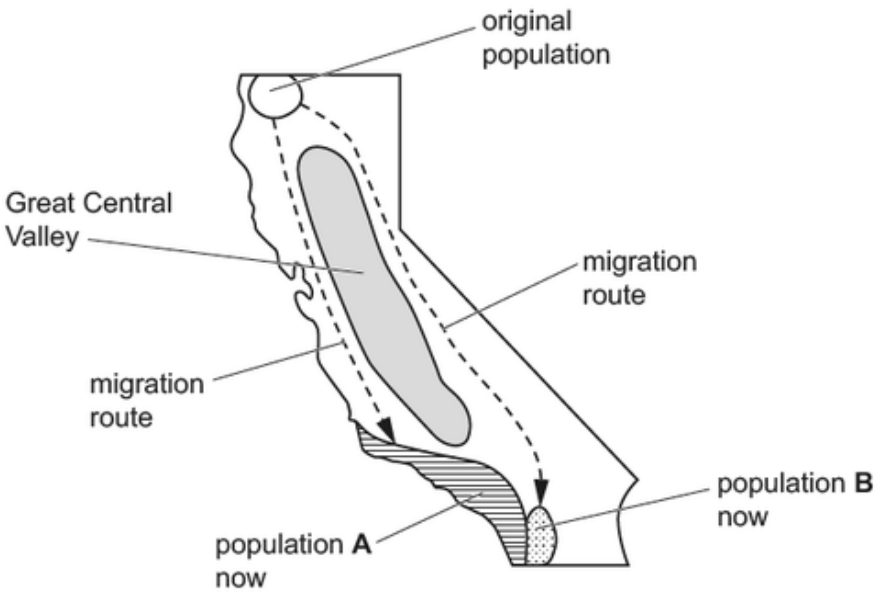


Fig. 8.1

STEMUP.CO.UK

Salamanders from population **A** rarely interbreed with salamanders of population **B**. If they do interbreed, the offspring are infertile.

Suggest **and** explain the sequence of events that have resulted in these two populations becoming reproductively isolated from each other.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 5]

STEMUP.CO.UK

2. Nov/2021/Paper_42/No.8

Twenty million years ago, an ocean covered the area where the country of Panama is now located. There was a gap between the continents of North America and South America through which the waters of the Atlantic and Pacific Oceans flowed freely.

The porkfish, *Anisotremus sp*, lived in this area between North America and South America.

Fig. 8.1 shows a porkfish.



Fig. 8.1

About 3 million years ago, volcanic activity and sedimentation formed a narrow strip of land, Panama, joining North America and South America.

Fig. 8.2 shows the area 20 million years ago and now.

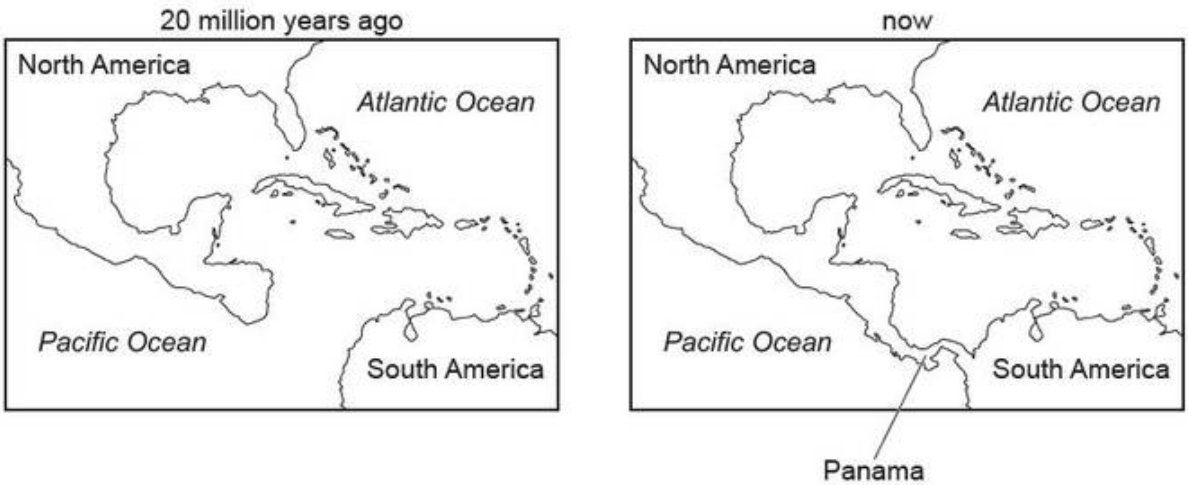


Fig. 8.2

STEMUP.CO.UK

Twenty million years ago, porkfish in the Atlantic and Pacific Oceans were able to breed successfully and produce fertile offspring.

Explain why Atlantic porkfish and Pacific porkfish are now **not** able to breed successfully to produce fertile offspring.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 5]

STEMUP.CO.UK

1. June/2022/Paper_41/No.5

Two subspecies of reindeer, *Rangifer tarandus*, live in North America. Members of the different subspecies belong to the same species but have some morphological differences and are found in different geographical locations.

Fig. 5.1 shows a reindeer.



Fig. 5.1

Table 5.1 compares the features of the two North American reindeer subspecies.

Table 5.1

feature	woodland subspecies, *R. tarandus caribou*	barren ground subspecies, *R. tarandus groenlandicus*
habitat	southern woodland (warmer)	northern tundra (colder)
type of food	tree leaves, grass	lichens, moss
summer and winter feeding grounds overlap	yes	no
carry out long migrations	no	yes
body size	large	small
colour of fur	dark	light

(a) During the last ice age an ice sheet separated southern and northern populations of *R. tarandus* in North America.

Explain how this ice sheet affected the evolution of *R. tarandus* to result in the two different subspecies.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Assess the relative importance of natural selection and genetic drift in producing:

(i) the different colours of fur of the two subspecies of reindeer

.....

.....

.....

.....

..... [2]

(ii) the different body sizes of the two subspecies of reindeer.

.....

.....

.....

.....

..... [2]

STEMUP.CO.UK

(c) Hybridisation has occurred between individuals of the two subspecies which now live in the area previously covered by the ice sheet.

Comment on how the hybrid populations compare to the pure subspecies in terms of genetic variation and potential to adapt to climate change.

.....

.....

.....

.....

.....

.....

..... [3]

(d) Outline how practical techniques could be used to test the hypothesis that migratory behaviour in reindeer has a genetic basis.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 14]

STEMUP.CO.UK

2. June/2022/Paper_42/No.5

Bison are a type of large wild cattle. Ancestors of modern bison appeared in Asia 2.5 million years ago. This ancestral bison species increased its range into Europe and North America.

While the ancestral species is now extinct, its descendants include *Bison bonasus*, the European bison, and *Bison bison*, the American bison.

Fig. 5.1 shows an American bison.



Fig. 5.1

(a) After the end of the last ice age, populations of the ancestral bison were separated by sea and by forests that were not suitable as habitats. The separation resulted in the evolution of the European bison and the American bison.

Explain how this separation resulted in the evolution of the two bison species.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

STEMUP.CO.UK

(b) Table 5.1 compares features of European bison and American bison.

Table 5.1

feature	European bison, *B. bonasus*	American bison, *B. bison*
type of food	grass and higher vegetation such as leaves of bushes and trees	grass and low vegetation
height/m	2.1	2.0
maximum mass/kg	1000	1270

Assess the relative importance of natural selection and genetic drift in producing the different heights and masses of the two species of bison.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(c) The European bison has a nuclear genome that is very similar to that of the American bison. The European bison has a mitochondrial genome that is more similar to that of wild cattle of the genus *Bos* than to the American bison.

Discuss what this implies about the evolutionary history of the European bison.

.....

.....

.....

.....

.....

..... [3]

STEMUP.CO.UK

(d) Outline how practical techniques could be used to test the hypothesis that farmed cattle are closely related to European bison.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 14]

STEMUP.CO.UK

3. June/2022/Paper_43/No.5

The puma, *Puma concolor*, lives in North and South America.

Fig. 5.1 shows a puma.

Fig 5.2 shows the distribution of the puma species.



Fig. 5.1

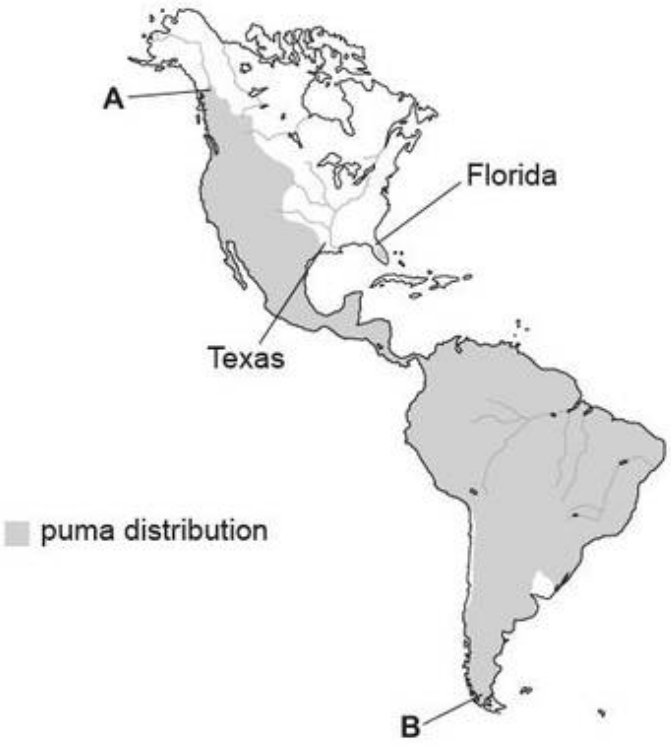


Fig. 5.2

STEMUP.CO.UK

(a) Members of different subspecies belong to the same species but have some morphological differences and are found in different geographical locations.

In the past the puma has been divided into 32 subspecies. The subspecies of puma varied in body size, coat colour and behaviour to adapt each population to its environment.

Explain how the different subspecies of puma evolved.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

In 2016, genetic analysis concluded that there are only two genetically distinct subspecies of puma, one in North and Central America and one in South America.

(b) Outline how practical techniques could be used to conduct a genetic analysis of the puma species.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

STEMUP.CO.UK

(c) Fig. 5.2 shows the location of an isolated puma population in Florida. In 1990, the size of this population was very small, with fewer than 30 individuals.

Three phenotypic features that vary in pumas are the shape of the tail, the pattern of hair growth on the back and the position of the testes in male pumas.

Variant forms of these phenotypic features that are normally rare occur at a high frequency in the small Florida population. These variant forms are:

- bent tail
- abnormal pattern of hair growth on the back
- testes remain in abdomen (undescended) in some male pumas.

(i) Predict, with reasons, whether these phenotypic features show a continuous or a discontinuous pattern of variation.

.....

.....

.....

.....

.....

..... [2]

(ii) Explain how the small size of the Florida population resulted in a high frequency of these normally rare variant forms.

.....

.....

.....

.....

.....

.....

..... [3]

STEMUP.CO.UK

(iii) In 1995, eight puma females from Texas were introduced to Florida to increase the breeding success and future size of the puma population in Florida. In the next 20 years the population grew substantially.

Suggest why the introduced females were taken from Texas and not from points **A** or **B** on Fig. 5.2.

.....

.....

.....

.....

..... [2]

[Total: 14]

STEMUP.CO.UK

1. Nov/2022/Paper_41/No.5

A large number of alpine plant species grow in the mountains of New Zealand's South Island. Alpine plants are defined as plants that live above the treeline, which is the height above which trees cannot grow. The current treeline for most of South Island is 1200 m.

(a) The alpine areas nearest to South Island are 1500–2000 km away across the sea. Many of South Island's alpine species live nowhere else in the world.

Explain how a large number of alpine plant species developed on South Island.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(b) Fig. 5.1 shows two aspects of the history of South Island over the last 3.9 million years.

- The dashed line shows how the mean height of mountains in the Clyde region of South Island increased over time. The mountains in this range have a mean height of 2400 m at the present time.
- The solid line models the height of the treeline over time based on geological climate data. The treeline was higher when the climate was warmer, and the treeline was lower when the climate was colder, during ice ages.

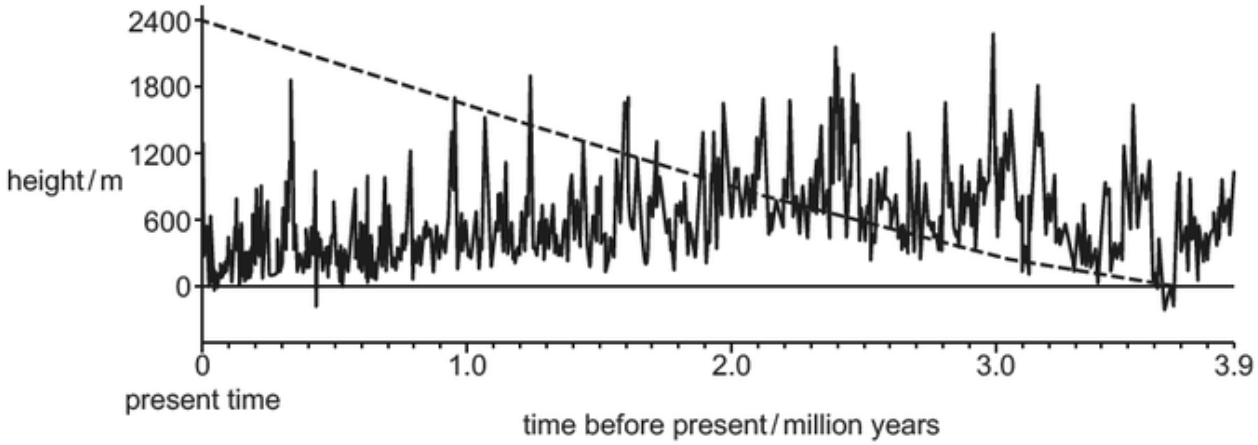


Fig. 5.1

(i) With reference to Fig. 5.1, identify with reasons the time period when South Island's alpine plant species developed.

.....

.....

.....

.....

.....

.....

..... [3]

(ii) Suggest how DNA sequence data could be used to confirm the time period you identified in **(i)**.

.....

.....

.....

.....

..... [2]

[Total: 10]

STEMUP.CO.UK

2. Nov /2022/Paper_42/No.1

The Asiatic lion, *Panthera leo persica*, is found only in the Gir Forest National Park in the Gujarat region of western India.

Fig. 1.1 shows a female Asiatic lion.



Fig. 1.1

(a) The Asiatic lion is at risk of extinction in the wild and is categorised as endangered by the International Union for Conservation of Nature (IUCN).

Outline the role of the IUCN.

.....

.....

.....

.....

.....

.....

..... [3]

STEMUP.CO.UK

(b) The Maldhari community is a tribe of herdsmen that lives in the Gir Forest. The Maldhari have co-existed with the Asiatic lions for thousands of years. The Maldhari place old and weak cattle at the edges of their cattle enclosures.

Suggest why the Maldhari place old and weak cattle at the edges of their cattle enclosures.

.....

.....

.....

.....

..... [2]

(c) Some zoos use assisted reproduction techniques, such as IVF, in their captive breeding programmes for endangered species.

Describe how IVF can be used with an endangered species such as the Asiatic lion.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 9]

STEMUP.CO.UK

3. June /2022/Paper_42/No.5

Myosotis is a genus of small flowering plants. Many different *Myosotis* species grow on the islands of New Zealand, which are an important site of *Myosotis* evolution. Lowland *Myosotis* species grow at low altitude while alpine *Myosotis* species grow at high altitude at the tops of mountains.

(a) Scientists wanted to obtain molecular data to determine the evolutionary relationships of New Zealand's *Myosotis* species. They extracted DNA from individuals of *Myosotis* species collected from three different islands in New Zealand.

To carry out a polymerase chain reaction before DNA sequencing, the DNA samples were mixed with primers, deoxynucleotides and *Taq* polymerase and put through 35 cycles of treatment. Each treatment cycle involved one minute at 95 °C, followed by one minute at 50 °C and then four minutes at 72 °C.

Describe what happened to the DNA at each temperature.

.....

.....

.....

.....

.....

..... [3]

STEMUP.CO.UK

(b) Fig. 5.1 shows the three largest New Zealand islands.

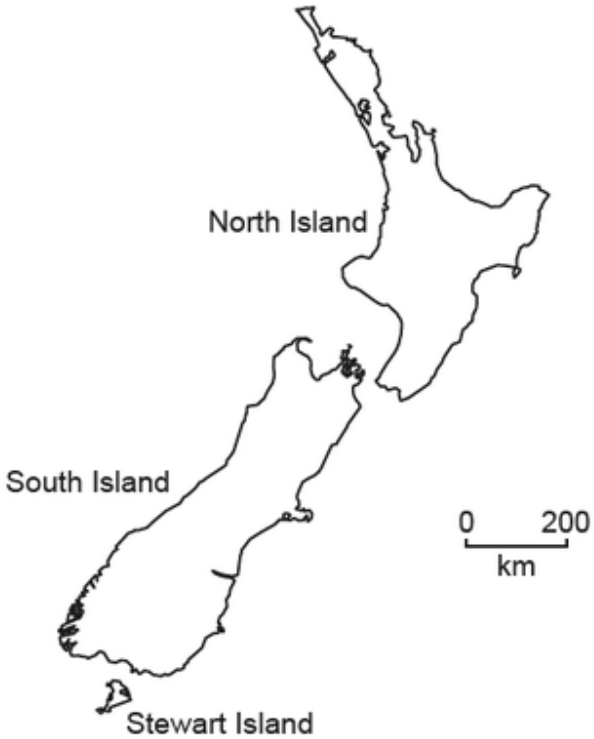


Fig. 5.1

North Island has mostly lowland habitat. South Island and Stewart Island have mountains with alpine habitats that are above the tree line.

DNA sequence data for three *Myosotis* species were compared. The results are described in the bullet points.

- In the alpine species *M. pygmaea*, individuals on South Island showed genetic differences from individuals of *M. pygmaea* on Stewart Island.
- In the alpine species *M. pulvinaris*, individuals from different mountains on South Island showed genetic differences.
- In the lowland species *M. pottsiana*, individuals from different areas of North Island showed overall genetic similarity.

STEMUP.CO.UK

Discuss reasons for the results in the three species.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(c) State **two** factors, other than natural selection, that could drive genetic changes in populations of *Myosotis*.

.....

.....

.....

.....

..... [2]

[Total: 10]

STEMUP.CO.UK

1. June/2023/Paper_ 9700/41/No.3

Oryza is a genus of grass plants that includes the rice, *Oryza sativa*, a food crop.

(a) Farmers flood fields of rice because this encourages faster growth and higher yields.

(i) An adaptation of rice plants that allows them to grow in water is the development of aerenchyma.

State the function of aerenchyma.

.....

.....

.....

.....

..... [2]

(ii) State **one other** way in which the roots of rice are adapted to being submerged in water.

.....

..... [1]

(iii) Another adaptation in some varieties of rice is the fast growth of stems.

Describe how selective breeding could produce varieties of rice with fast-growing stems.

.....

.....

.....

.....

.....

..... [3]

STEMUP.CO.UK

(iv) Auxin is a plant growth hormone that affects the growth of rice stems.

Explain how auxin affects the growth of rice stems.

.....

.....

.....

.....

.....

..... [3]

(b) *O. rufipogon* and *O. nivara* are two species of wild rice.

- *O. rufipogon* grows in places where water is always available.
- *O. nivara* grows within the same geographical range as *O. rufipogon*.
- The habitat of *O. nivara* can lack water for part of the year.
- The two species flower at different times of the year.

These two rice species may have evolved by sympatric speciation.

Explain how *O. rufipogon* and *O. nivara* may have evolved through sympatric speciation.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 12]

STEMUP.CO.UK

2. June/2023/Paper_ 9700/42/No.3

(a) The sea blush, *Plectritis congesta*, is a flowering plant that grows on the west coast of North America.

Individual sea blush plants produce fruit that is either winged or wingless. Investigations have shown that this characteristic is controlled by a single gene with two alleles:

- a dominant winged fruit allele
- a recessive wingless fruit allele.

Fig. 3.1 shows the difference in structure between winged fruit and wingless fruit phenotypes.

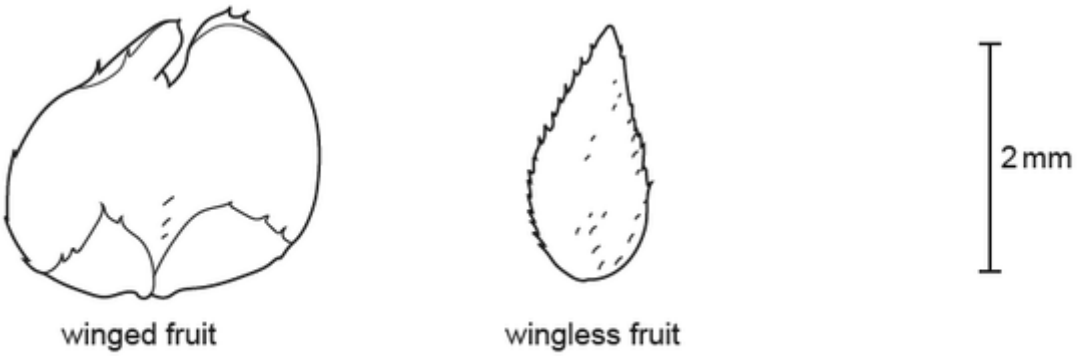


Fig. 3.1

(i) A large sample of sea blush fruits was collected and their fruit-wing characteristic was recorded.

Name the type of variation that is shown for the fruit-wing characteristic of the sea blush.

..... [1]

(ii) Different sea blush plants can have fruit with different colours.

Suggest **two** ways in which a new fruit colour could naturally occur in a sea blush population.

.....

.....

.....

..... [2]

STEMUP.CO.UK

(iii) Early taxonomists classified sea blush plants with winged fruits as a different species to sea blush plants with wingless fruits.

Since this time, evidence from observations and experiments has confirmed that the plants belong to the same species.

Suggest **three** examples of the evidence obtained that helped to confirm that these sea blush plants belong to the same species.

.....

.....

.....

.....

.....

.....

..... [3]

(b) Natural selection occurs in populations, such as in populations of sea blush plants.

Explain why natural selection occurs in populations.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 11]

STEMUP.CO.UK

3. June/2023/Paper_ 9700/43/No.2

Humans use antibiotics to treat bacterial infections. The increased use of antibiotics has led to an increase in the number of strains of bacteria that are resistant to antibiotics.

The evolution of antibiotic resistance in bacteria has resulted from natural selection.

Outline how bacteria become resistant to antibiotics.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

[Total: 7]

STEMUP.CO.UK

Selection and evolution – 2023 November Biology A2 9700

1. Nov/2023/Paper_9700/42/No.2

Yeasts are unicellular organisms from the kingdom Fungi. *Saccharomyces cerevisiae* is one species of yeast that can carry out either asexual reproduction by mitosis or sexual reproduction by meiosis.

Budding in *S. cerevisiae* is a process where a small daughter cell forms as a bud on the parent cell. The bud contains a copy of the parent cell nucleus and it eventually separates from the parent cell to form a new cell.

S. cerevisiae can exist in two forms: haploid cells or diploid cells.

- Haploid cells can be one of two different mating types: **a** and **α**.
- Haploid cells can only mate with other haploid cells of the opposite mating type.

Fig. 2.1 shows the life cycle of *S. cerevisiae* with its asexual and sexual reproductive stages.

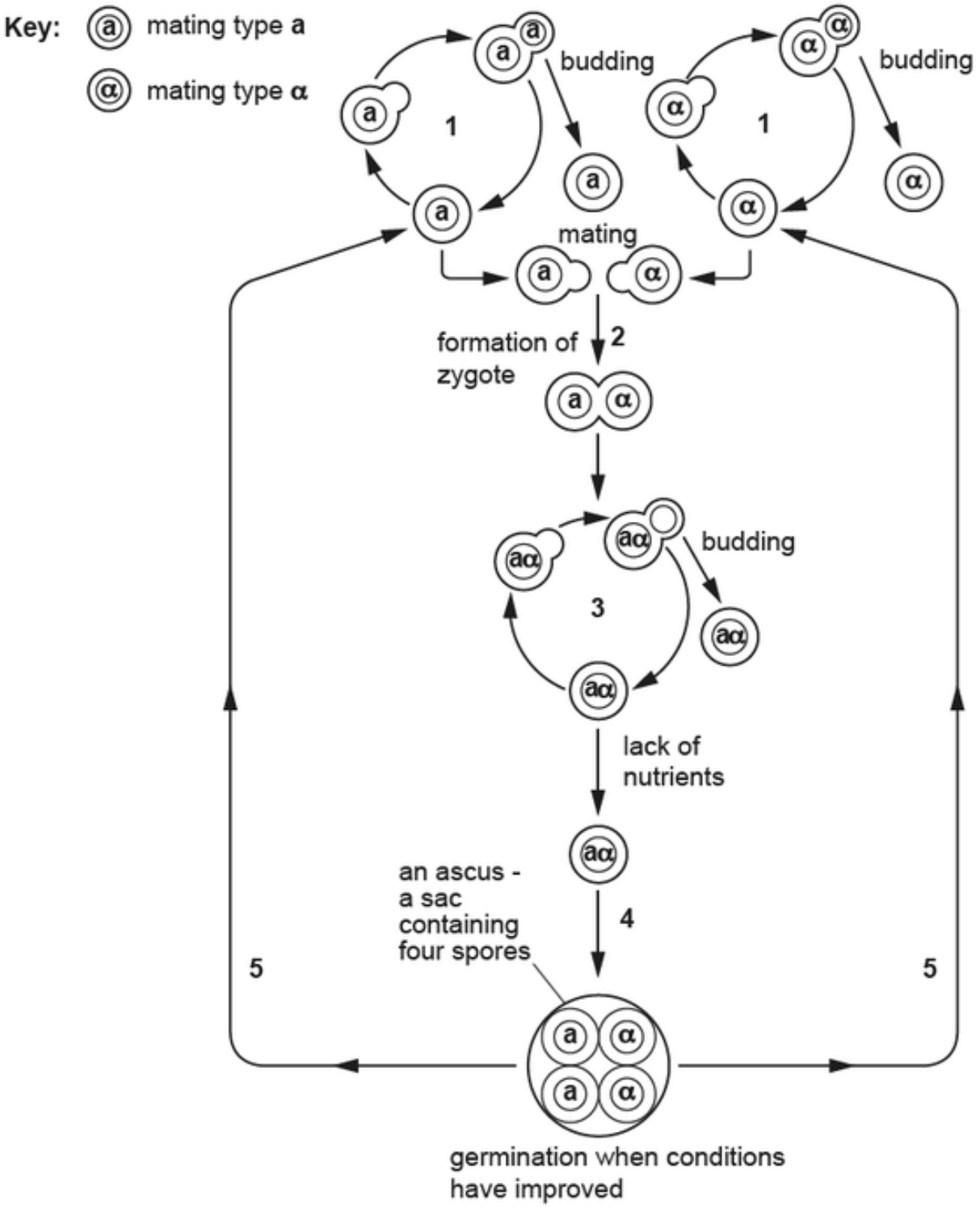


Fig. 2.1

STEMUP.CO.UK

(a) With reference to Fig. 2.1, state the numbers of the stages **1–5** that:

involve mitosis .....

involve meiosis .....

produces new genetic variation .....

shows only haploid cells .....

shows only diploid cells .....

[5]

(b) When there is a lack of nutrients, cells made in stage **3** will carry out stage **4** to make spores, which germinate only when conditions improve.

Suggest **and** explain how the type of reproduction that makes spores during stage **4** is advantageous for *S. cerevisiae* in a changing environment.

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) Haploid and diploid cells of *S. cerevisiae* can carry out **asexual** reproduction.

Suggest why a new harmful recessive mutation may **not** have a damaging effect on:

- an asexually reproducing population of haploid cells of *S. cerevisiae*
- an asexually reproducing population of diploid cells of *S. cerevisiae*.

.....

.....

.....

.....

.....

.....

..... [3]

STEMUP.CO.UK

(d) State **two** features, other than reproduction using spores, of the kingdom Fungi.

.....

.....

..... [2]

[Total: 14]

STEMUP.CO.UK

2. Nov/2023/Paper_9700/42/No.3

Research suggests that selective breeding began about 10 000 years ago. Selective breeding has been important in satisfying the global demand for food.

(a) The introduction of disease resistance to varieties of wheat is an example of selective breeding.

Outline the steps involved in the introduction of disease resistance to varieties of wheat.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(b) Suggest **two** possible disadvantages of selective breeding.

.....

.....

.....

.....

..... [2]

[Total: 7]

STEMUP.CO.UK