**Write your name, centre number and candidate number in the boxes below.**

| Surname | Other names |
|---|---|
| | |

Centre number | | | | | |

Candidate number | | | | |

**STEM** | Exam Builder

# Variation and selection

Time allowed: 1 hour 30 minutes

**Subject code** **0610**

# Biology

## Questions from Paper 3, Paper 4 and Paper 6

**You must have:** a ruler marked in centimetres and millimetres, a protractor, compasses, a pen, an HB pencil and an eraser.

Total marks

**/ 90**

### Instructions

- Answer every question in the space provided on this paper.
- Write in black or dark blue ink. Pencil may be used for diagrams and graphs.
- Fill in your name, centre number and candidate number above.
- Show your working: a correct method can earn marks even if the answer is wrong.

### Information

- This paper has 10 questions worth 90 marks in total.
- The marks for each question or part are shown in brackets, for example [3].

### Advice

- Read every question through once before you write anything.
- Use the marks in brackets to judge how long to spend on each part.
- If you finish early, go back and check your working.

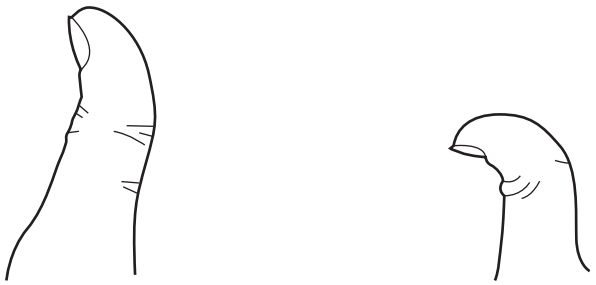
STEM | Exam Builder



Print at 100% (Actual size) so diagrams keep their real measurements.

**1** There is variation in the shape of human thumbs.

Fig. 3.1 shows the two forms referred to as ‘straight’ and ‘hitch hikers’.



straight hitch hikers

**Fig. 3.1**

A survey of thumb shape was carried out on 197 students. The results are shown in Table 3.1.

**Table 3.1**

| age / years | number of students with ‘straight’ thumbs | | number of students with ‘hitch hiker’ thumbs | |
|---|---|---|---|---|
| | male | female | male | female |
| 12 | 21 | 24 | 4 | 2 |
| 13 | 18 | 28 | 3 | 5 |
| 14 | 19 | 15 | 2 | 3 |
| 15 | 26 | 20 | 3 | 4 |
| total | 84 | 87 | 12 | 14 |

**(a)** Describe the results shown in Table 3.1.

.....

.....

.....

.....

..... [3]

STEM | Exam Builder

**(b)** Scientists think that thumb shape is controlled by a single gene.

What evidence is there from Table 3.1 to support this idea?

.....

.....

..... [3]

[Total : 6]

Measurements, tables, graphs and conclusions Click for more variations

Reduced to 78% to fit the page (wider than A4).

| | | | |
|---|---|---|---|
| **1 (a)** | more with straight thumb ORA;<br><br>correct reference to figures for gender e.g.<br>**straight**: 84 males and 87 females / more females / less males<br>**and /or**<br>**hitch hiker**: 12 males and 14 females / more females / less males;<br><br>independent of their age /AW; | [3] | **A.** correct reference to figures e.g. 171 straight and 26 hitch hiker or approx 87% straight / 13% hitch hiker.<br>**A.** independent of gender;<br><br>**I.** references to figures or differences in age groups.<br>**A.** varies with age |
| **(b)** | discontinuous variation ;<br>no range of results / only two types /AW;<br>hitch hiker thumb recessive (allele);<br>straight thumb dominant (allele);<br>not linked to sex / gender;<br>not affected by age; | [max 3] | **I.** gene<br>**I.** codominant<br><br>**I.** Punnett squares |
| | | **[Total: 6]** | |

STEM | Exam Builder

2 Blood group is an example of discontinuous variation.

The blood groups of patients in a hospital were recorded.

Fig. 8.1 shows the results.

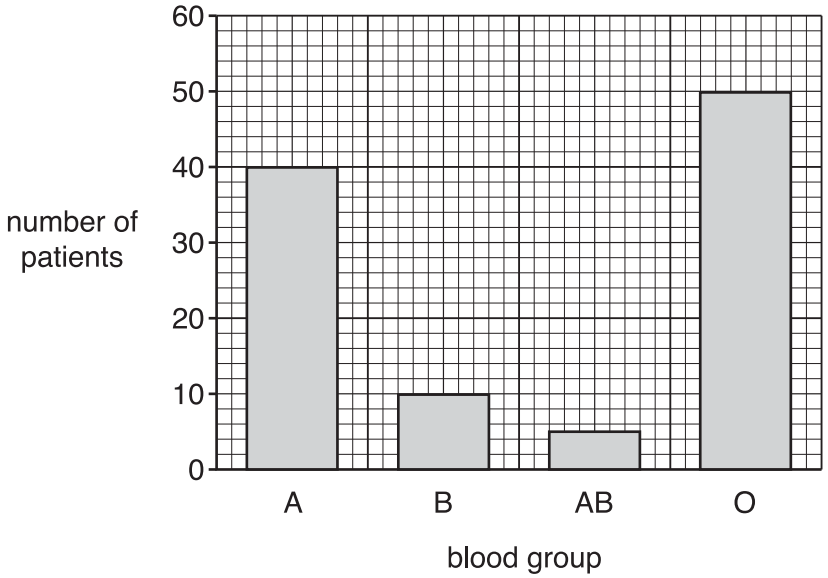



**Fig. 8.1**

**(a)** Explain how Fig. 8.1 shows that blood group is an example of discontinuous variation.

.....

.....

.....[1]

**(b)** Table 8.1 shows different examples of variation.

Tick all the boxes that show examples of discontinuous variation.

**Table 8.1**

| | |
|---|---|
| attached or unattached earlobes | |
| foot length | |
| gender (male or female) | |
| height | |
| tongue rolling | |
| weight | |

[3]

STEM | Exam Builder

**(c)** Variation can be caused by mutation.

The word mutation can be connected to the words in the boxes on the right to make a complete sentence.

Draw **three** lines to join the word 'mutation' to the words in the boxes to make three correct sentences.

| | |
|---|---|
| Mutation | is a genetic change. |
| | is a change in the environment. |
| | only occurs in plants. |
| | forms new alleles. |
| | changes your physical appearance only. |
| | can be caused by ionising radiation. |

[3]

[Total: 7]

Variation and mutation Click for more variations

Reduced to 77% to fit the page (wider than A4).

| | | | |
|---|---|---|---|
| 2(a) | limited number of, phenotypes / categories / groups ;<br>no intermediates / AW ; | 1 | |
| 2(b) | attached or unattached earlobes ✓<br>foot length<br>gender (male or female) ✓<br>height<br>tongue rolling ✓<br>weight<br>;;; | 3 | deduct one for each additional box ticked |
| 2(c) | is a genetic change ;<br>forms new alleles ;<br>can be caused by ionising radiation ; | 3 | deduct one for each additional line |

STEM | Exam Builder

**3** An *adaptive feature* helps an organism survive in its environment.

Adaptive features are inherited.

Fig. 5.1 contains diagrams of three animals.

**(a)** For each animal, select **one** adaptive feature visible in Fig. 5.1 and briefly suggest how it helps the animal to survive.

An example has been done for you.

**not drawn to scale**

**animal C**

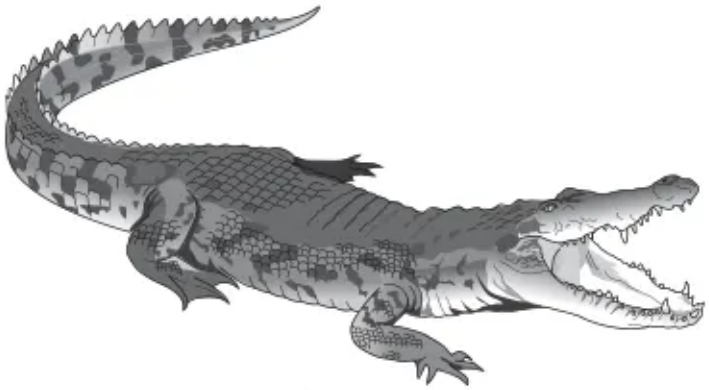


red deer

adaptive feature: antlers (horns) on head

help in survival: used for defence against predators

**animal D**



saltwater crocodile

adaptive feature: .....

help in survival: .....

.....

.....

**animal E**



golden eagle

adaptive feature: .....

help in survival: .....

.....

.....

**Fig. 5.1**

[4]

STEM | Exam Builder

**(b)** Fig. 5.2 shows a giraffe and an okapi.

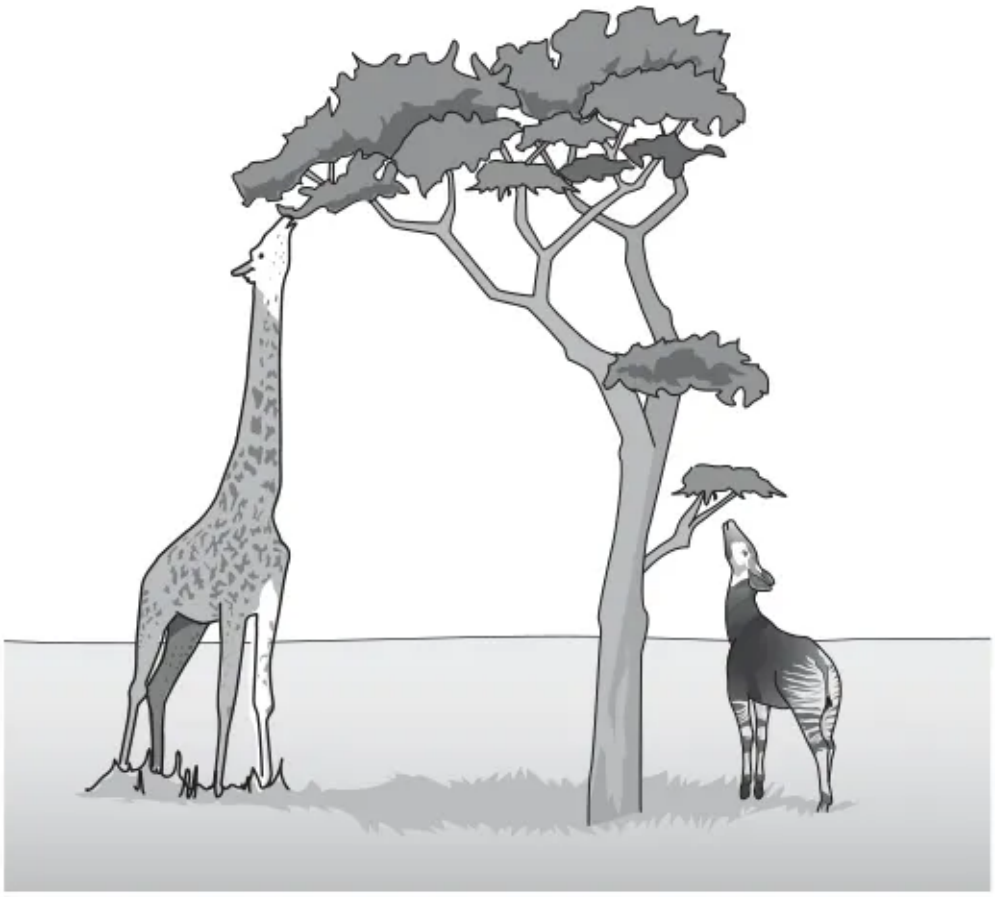


**Fig. 5.2**

The long neck is an adaptive feature for giraffes.

It helps them feed on leaves that other animals like the okapi cannot reach.

Giraffes developed long necks by the process of natural selection.

STEM | Exam Builder

The statements in Table 5.1 are about how natural selection occurred in giraffes.

**Table 5.1**

| statement number | statement |
|---|---|
| 1 | More giraffes are born than can survive. |
| 2 | Giraffes have necks of different length. |
| 3 | The giraffes with the longest necks survive and reproduce. |
| 4 | There is competition for food between giraffes. |
| 5 | The surviving giraffes pass on their alleles for long necks to their offspring. |

Arrange these statements in a sequence to explain how natural selection occurred in giraffes.

One has been done for you.




[3]

**[Total: 7]**

Adaptive features Click for more variations

STEM | Exam Builder

**3**(a)

| D / E | adaptive feature | help in survival |
|---|---|---|
| **D** | (canine) teeth<br>large mouth / jaws / beak<br>(long / strong), tail<br>webbed, toes / feet<br>scaly / rough, skin / has scales<br>markings / AW<br>eyes on top of head<br>AVP<br>; | seize / eat prey<br>swallow / catch / grip large prey<br>swimming / defence<br>swimming<br>prevent dehydration / waterproof<br>for camouflage<br>vision when submerged<br>; |
| **E** | claws / nails / talons<br>beak<br>wings<br>(tail) feathers<br>forward facing eyes<br>AVP<br>; | catch / tear prey / perching / defence<br>tear / hold food / offence / defence<br>flight / search for prey / hunt / escape predators<br>retain body heat / helps in flight<br>to see prey from a distance<br>; |

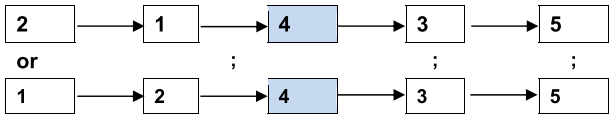
**4**

feature and reason must match

feature must be **visible**

AW throughout

**3**(b)




**3**

1 and 2 at start in either order
3 after 4 (somewhere)
5 at the end

STEM | Exam Builder

**4** Fig. 9.1 shows a potato plant.

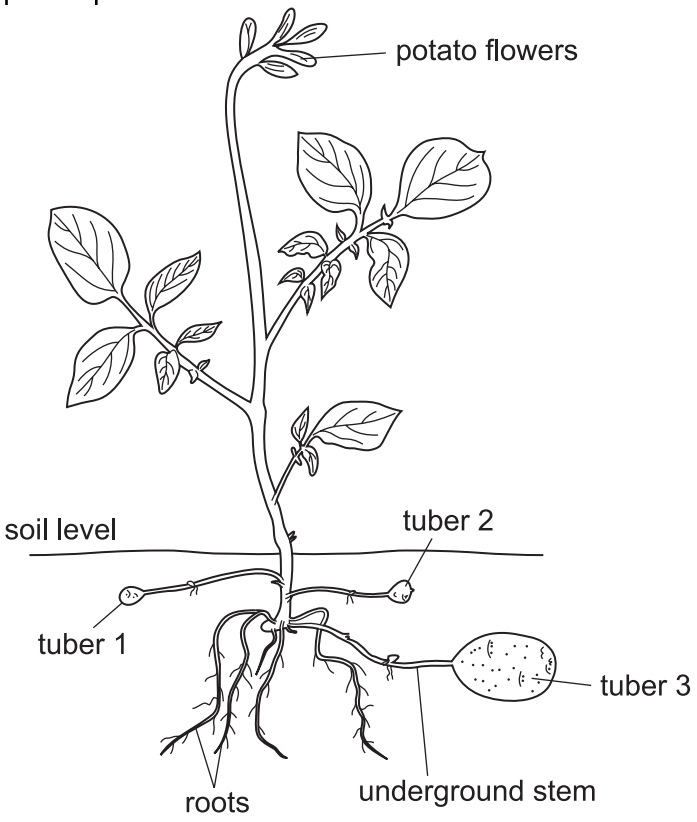



**Fig. 9.1**

As the plant grows, buds on the underground stem grow into side shoots.
The ends of these shoots swell to form tubers.
The tubers can grow into new plants.

**(a) (i)** Which type of nuclear division will occur at the end of a shoot as a tuber develops?

.....

[1]

**(ii)** The three tubers, shown in Fig. 9.1, are each grown to form separate plants.
They all show the same characteristics as the parent plant.

Explain why this happens.

.....

.....

[1]

STEM | Exam Builder

**(iii)** After two months the three new plants were different sizes.

Suggest **two** reasons why the plants were different.

1 .....

.....

2 .....

..... [2]

**(b)** The potato plant has purple flowers that are usually insect-pollinated. After pollination the seeds formed can grow into new plants.

**(i)** Explain why these plants may show features different from the parent plants.

.....

.....

.....

.....

.....

..... [3]

**(ii)** A scientist has two varieties of potato.

One variety has disease resistance and the other variety grows well in dry soil.

Suggest how the scientist could produce a new variety with both of these characteristics.

.....

.....

.....

.....

.....

..... [3]

**[Total: 10]**

Variation and mutation Click for more variations

STEM | Exam Builder

| | | | |
|---|---|---|---|
| **4 (a) (i)** | mitosis / mitotic; | [1] | |
| **(ii)** | will all have identical genetic make-up / asexual reproduction happening; | [1] | A – same genotype |
| **(iii)** | 1 different growing conditions / competition;<br>2 e.g. light / water / minerals etc;<br>3 damage due to disease / pests;<br>4 original tubers of different sizes;<br>5 age of tubers / time since planting; | max [2] | Any two – 1 mark each<br>A – nutrients |
| **(b) (i)** | 1 sexual reproduction happening;<br>2 male gametes / pollen can come from any plant;<br>3 gametes / pollen may vary as formed by meiosis;<br>4 different combinations of genes / alleles possible; | max [3] | Any three – 1 mark each<br>A – ref to self / cross pollination |

| | | | |
|---|---|---|---|
| **(ii)** | 1 select plants with desired characteristics / breed the two varieties with one another / OWTTE;<br>2 isolate flowers;<br>3 remove stamens from some / stigmas from others;<br>4 cross pollinate;<br>5 collect seeds;<br>6 grow plants to check success;<br>7 select next generation of plants / discard any without one of the features;<br>8 repeat process; | max [3] | Any three – 1 mark each<br>A – remove anthers, carpels<br>A – ref to genetic modification;<br>A – AVP for GM |
| | | **[Total: 10]** | |

STEM | Exam Builder

5 The Galápagos Islands are a group of small islands in the Pacific Ocean.

In 1839 Charles Darwin published a book that described differences in a family of birds called finches.

Each species of Galápagos finch had:

- a different diet
- a different beak shape, as shown in Fig. 5.1.

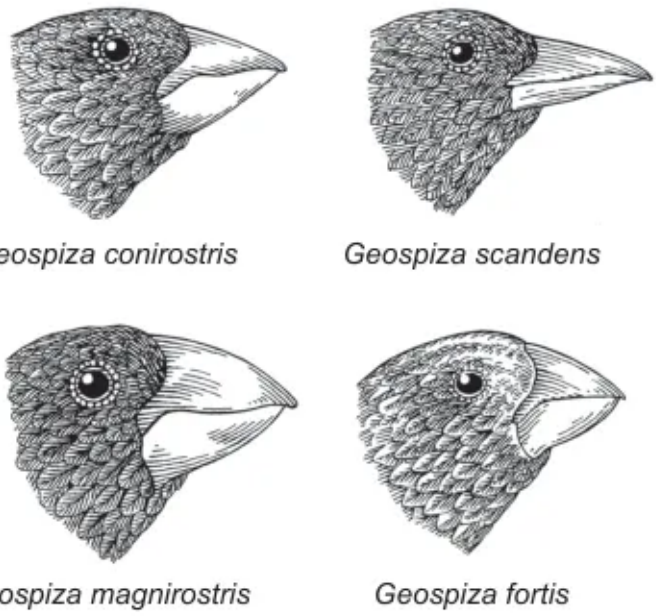



**Fig. 5.1**

**(a)** State the genus name for the Galápagos finches shown in Fig. 5.1.

..... [1]

STEM | Exam Builder

**(b)** Galápagos finches share a common ancestor.

Suggest how Galápagos finches have evolved different shaped beaks.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 6]

Natural and artificial selection Click for more variations

Reduced to 78% to fit the page (wider than A4).

| | | |
|---|---|---|
| 5(a)(i) | *Geospiza* ; | **1** |
| 5(a)(ii) | *any five from:*<br>natural selection ;<br>variation (in beak shapes) ;<br>mutation / description ;<br>those birds with, selective advantage / unique beak shape, more likely to find food and survive ;<br>the birds that survive reproduce ;<br>pass on their alleles ;<br>continues over many generations ;<br>AVP ; | **5** |

STEM | Exam Builder

**6** An ecologist studied variation in a species of xerophyte.

**(a)** Xerophytes are adapted to a particular type of environment.

State this type of environment.

.....[1]

**(b)** The ecologist studied the features of the leaves in the species of xerophyte.

Fig. 5.1 shows the variation in the type of leaf spike.

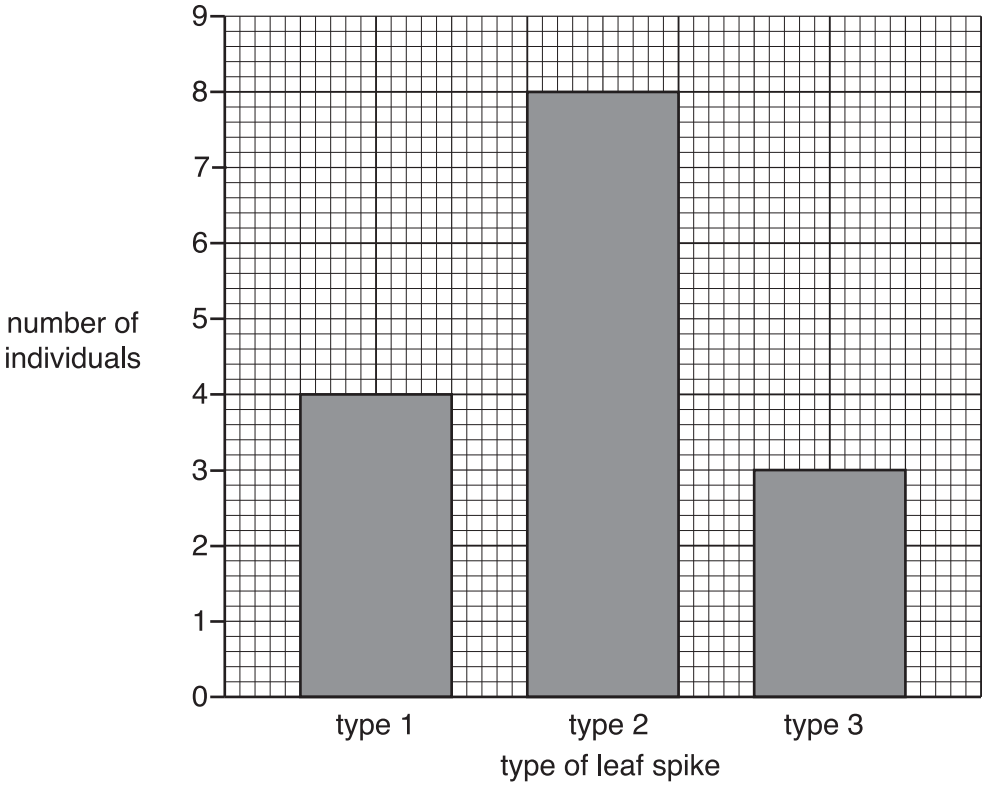



**Fig. 5.1**

**(i)** State the type of variation shown in Fig. 5.1.

.....[1]

**(ii)** Explain why the type of leaf spike is an example of the variation shown in Fig. 5.1.

.....

.....

.....[2]

STEM | Exam Builder

**(c)** The ecologist also measured other features of the leaves.

Fig. 5.2 shows the variation in leaf feature **B**.

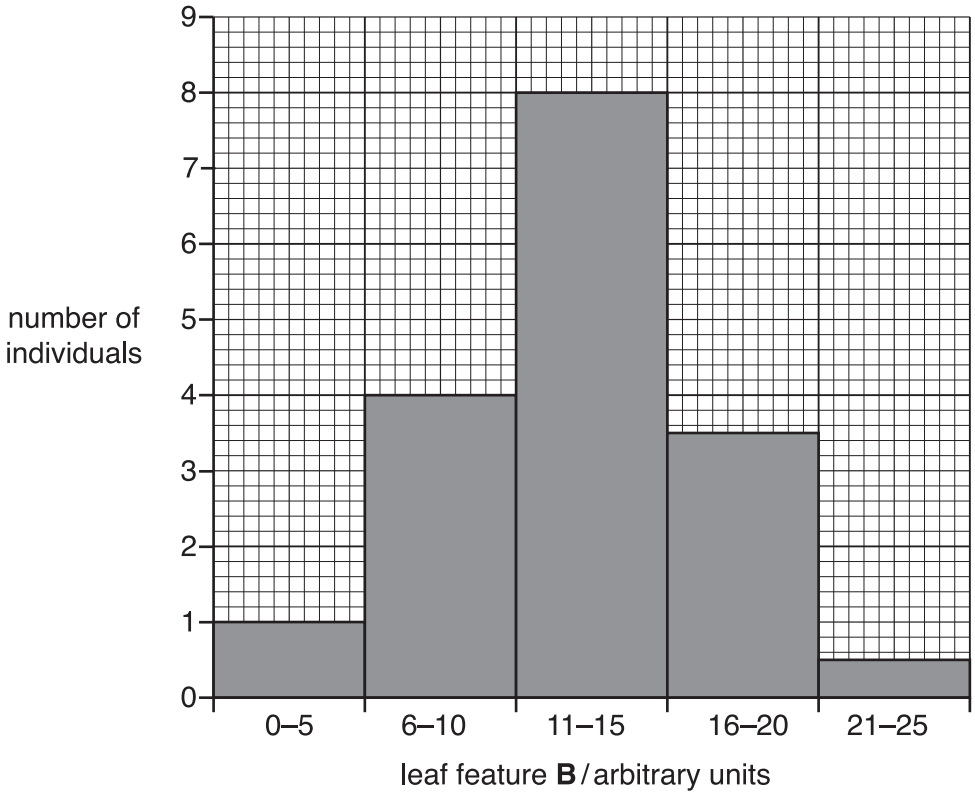



**Fig. 5.2**

State **two** named features of leaves that show the type of variation shown in Fig. 5.2.

1 .....

2 .....

[2]

STEM | Exam Builder

**(d)** After one year, the ecologist recorded the variation in leaf feature **B** again.

The results are shown in Fig. 5.3.

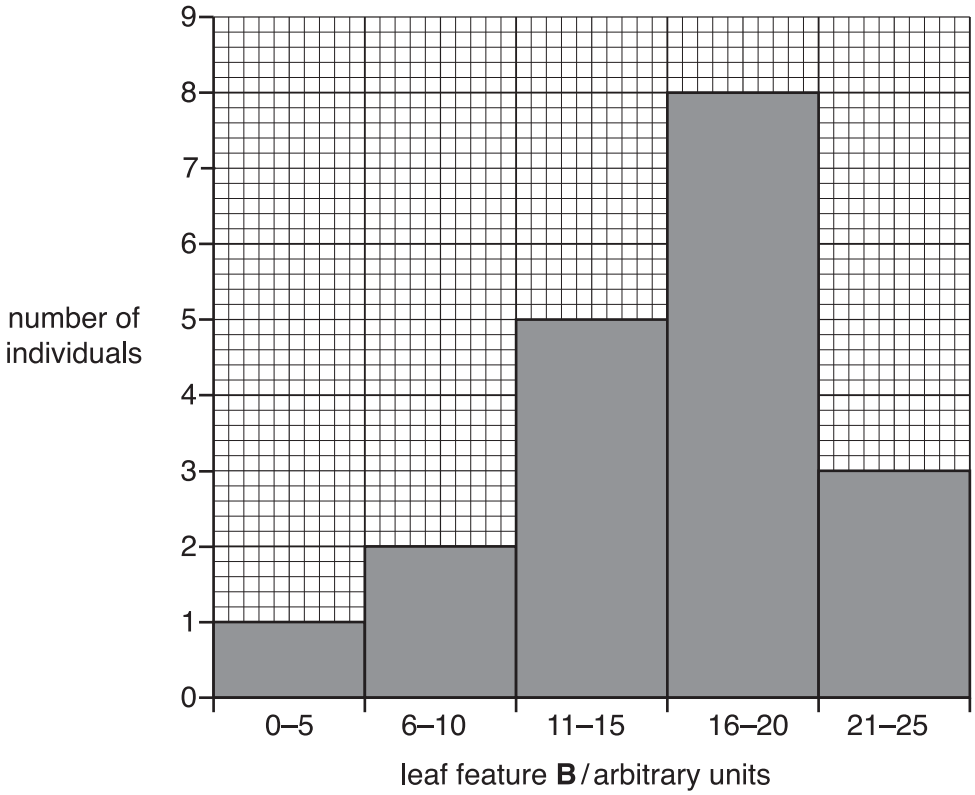



**Fig. 5.3**

Suggest **one** reason for the difference in variation of leaf feature **B** after one year.

.....

.....[1]

[Total: 7]

Variation and mutation Click for more variations

Reduced to 75% to fit the page (wider than A4).

| | | | |
|---|---|---|---|
| **6**(a) | dry / AW ; | **1** | |
| **6**(b)(i) | discontinuous ; | **1** | |
| **6**(b)(ii) | limited number of phenotypes / three categories ;<br>no intermediates / discrete / separate categories / AW ;<br>caused by genes only ;<br>bar chart (has gaps) ; | **2** | |
| **6**(c) | thickness / length / width / mass / concentration of pigment / volume / surface area, of any leaf feature / density of stomata / number of, veins / chloroplasts / spikes ;; | **2** | **A** concentration for density |
| **6**(d) | measured different leaves ;<br>change in (named) environmental (feature) ;<br>adapted to environment ;<br>leaves / plant, have, grown / older ;<br>AVP ; | **1** | **A** mutation |

STEM | Exam Builder

7 Xerophytes are plants that show adaptive features for dry habitats.

**(a)** Complete the sentence to define the term adaptive feature.

An adaptive feature is an ..... feature that helps an organism to ..... and ..... in its environment.

[2]

**(b)** Marram grass is a xerophytic plant.

Fig. 4.1 is a photomicrograph of a cross-section of a marram grass leaf.

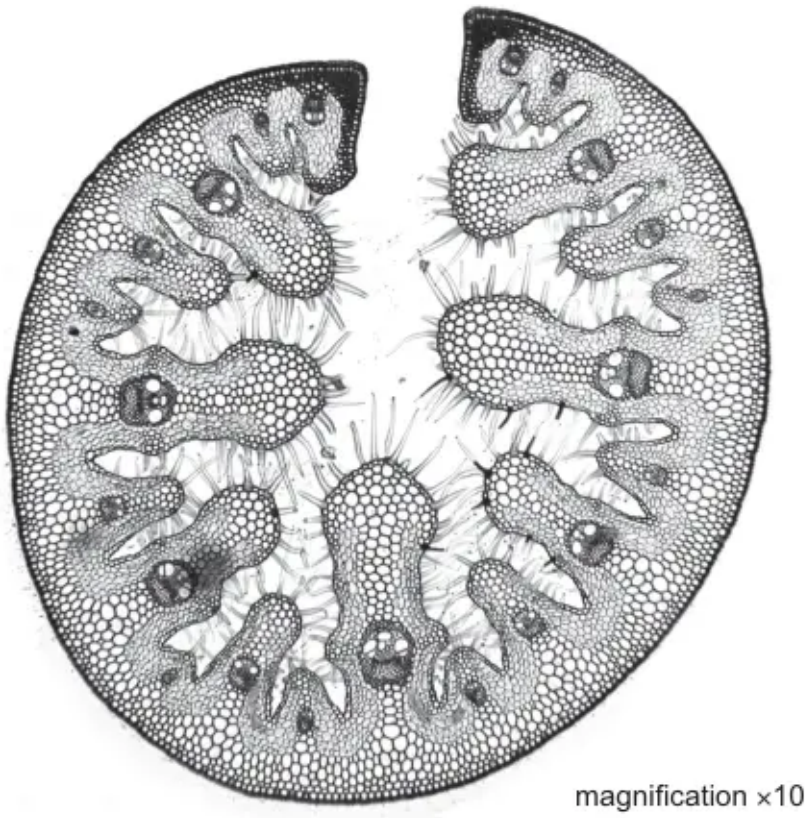



**Fig. 4.1**

Using Fig. 4.1, describe the visible features that identify this as a xerophyte leaf.

.....

.....

.....

.....

..... [2]

**(c)** **(i)** The mean cell wall thickness of an epidermal cell from one species of xerophyte is 1.276 μm.

Convert 1.276 μm to mm.

..... mm [1]

**(ii)** State the name of the carbohydrate molecule used to build cell walls in xerophytes.

..... [1]

**(iii)** Suggest **one** way the stem of a xerophyte is adapted for dry habitats.

.....

.....

..... [1]

**(d)** Fig. 4.2 is a diagram showing the root systems of two different species of xerophyte.

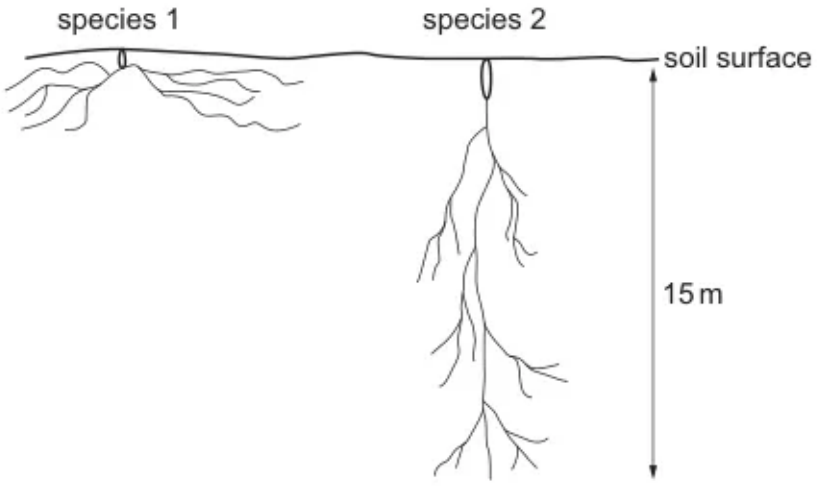



**Fig. 4.2**

Describe the **two** root systems shown in Fig. 4.2 **and** suggest how each one is an adaptation for living in a dry environment.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

Adaptive features Click for more variations

| | | | |
|---|---|---|---|
| 7(a) | inherited ;<br>survive (and) reproduce / breed / produce offspring ; | **2** | either order |
| 7(b) | *any two from:*<br>curled / rolled, leaf ;<br>inner surface is folded ;<br>hairs / AW ;<br>few / sunken, stomata **OR** stomata in, pits / AW ;<br>thick cuticle ; | **2** | |
| 7(c)(i) | 0.001276 / 1.276 $\times$ $10^{-3}$ (mm) ; | **1** | |
| 7(c)(ii) | cellulose ; | **1** | |
| 7(c)(iii) | *any one from:*<br>swollen / thick (stem) **OR** water storage / succulent ;<br>chloroplasts / site of photosynthesis ;<br>thick (waxy) cuticle ;<br>AVP ; | **1** | **A** wide stem |
| 7(d) | *any three from:*<br>*species 1:*<br>1 roots, shallow / close to the surface **OR** spread, out(wards) / over a wide area (of the soil surface) ;<br>2 to absorb water immediately after rainfall / from the (soil) surface ;<br><br>*species 2:*<br>3 deep / long (vertically), root ;<br>4 to absorb, ground / deep, water (in the soil) ; | **3** | |

STEM | Exam Builder

**8** **(a)** Fig. 1.1 shows seven species of fish that live on reefs in the Caribbean.

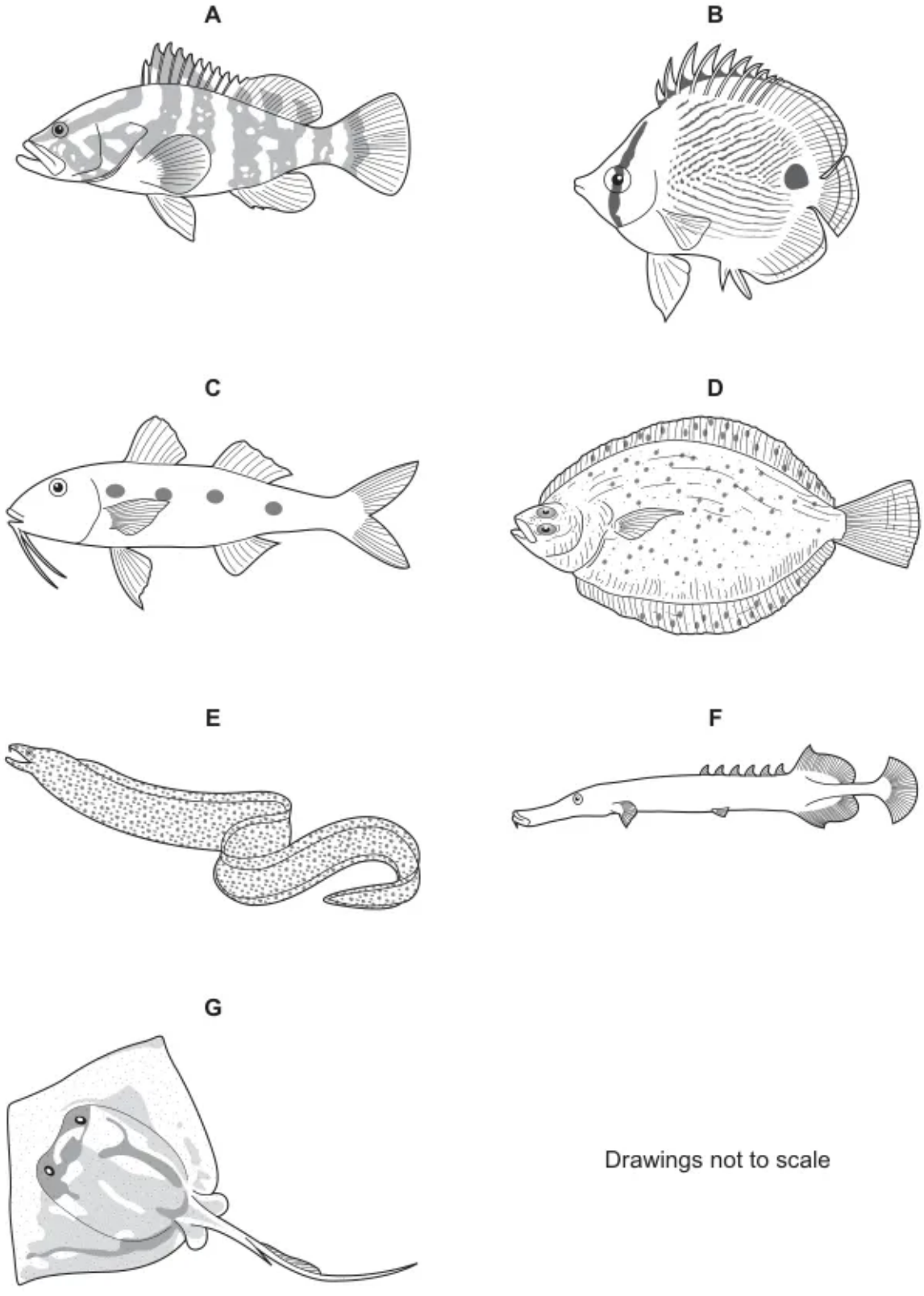



**Fig. 1.1**

Use the key to identify each species. Write the letter of each species (**A** to **G**) in the correct box beside the key. One has been done for you.

**Key**

| | | | |
|---|---|---|---|
| 1 (a) | Body shape is long and narrow, at least 10 times as long as its depth | go to 2 | |
| (b) | Body shape is not long and narrow, less than 10 times long as its depth | go to 3 | |
| 2 (a) | Fins are pointed | *Aulostomus maculatus* | **F** |
| (b) | Fins are smooth | *Gymnothorax moringa* | |
| 3 (a) | Both eyes are on top of the head | go to 4 | |
| (b) | Eyes are on either side of the head | go to 5 | |
| 4 (a) | Tail fin is long and thin | *Dasyatis americana* | |
| (b) | Tail fin is short | *Bothus ocellatus* | |
| 5 (a) | Fish has one or several dark spots | go to 6 | |
| (b) | Fish has no dark spots | *Epinephelus striatus* | |
| 6 (a) | Fish has two fins on its back | *Pseudupeneus maculatus* | |
| (b) | Fish has more than two fins on its back | *Chaetodon capistratus* | |

[4]

STEM | Exam Builder

The wavelengths of light that penetrate water influence the features of fish. Blue light does not penetrate far into water; red light penetrates much further.

Many different species of cichlid fish live in Lake Victoria in Africa. Some species live in shallow water and others live in deeper water.

Table 1.2 summarises some of the features of males and females of these species.

**Table 1.2**

| habitat | body colour of males | retina in eyes of females |
|---|---|---|
| shallow water | blue | detects blue light |
| deep water | red | detects red light |

Body colour and colour vision are both inherited features. Females select the males that they mate with and prefer bright coloured males. Male and female eyes of the same species of cichlid fish are similar.

**(b) (i)** The ancestors of red and blue cichlid fish were brown.

State how the different body colours of the males first happened.

.....

..... [1]

**(ii)** Suggest the advantages of different cichlid fish being able to detect blue and red light.

.....

.....

.....

.....

..... [2]

STEM | Exam Builder

**(c)** Lake Victoria receives considerable pollution from the surrounding area which makes the water cloudier and reduces the penetration of blue light.

Suggest and explain the likely long-term effects of the cloudy water on the red and blue cichlid fish.

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 11]

Classification, species and dichotomous keys Click for more variations

Reduced to 77% to fit the page (wider than A4).

**8 (a)**

***5 / 6 RIGHT = 4***
***4 RIGHT = 3***
***3 RIGHT = 2***
***1 / 2 RIGHT =1***

***0 RIGHT = 0***

| | |
|---|---|
| go to 2 | |
| go to 3 | |
| *Aulostomus maculatus* | **F** |
| *Gymnothorax moringa* | **E** |
| go to 4 | |
| go to 5 | |
| *Dasyatis americana* | **G** |
| *Bothus ocellatus* | **D** |
| go to 6 | |
| *Epinephelus striatus* | **A** |
| *Pseudupeneus maculatus* | **C** |
| *Chaetodon capistratus* | **B** |

[4]

sequence is:

**E**
**G**
**D**
**A**
**C**
**B**

**I** letters placed in grey blocks

**(b) (i)** mutation ; [1]

**(ii)**

| | |
|---|---|
| **1** | retina / pigments, adapted for detecting different, colours / wavelengths ; |
| **2** | colours / wavelengths, for different depths ; |
| **3** | fish are adapted to live at different depths ; |
| **4** | as a group fish will occupy a larger habitat ; |
| **5** | blue/red, retinal detector mates with relevant, type / species / AW ; |
| **6** | avoid competition ; |

[max 2]

**R** simple restatement of the question stem

**(c)**

| | |
|---|---|
| **1** | reduces ability of blue fish to find mates ; |
| **2** | reduces reproduction in blue fish ; |
| **3** | number of blue fish, decrease / become rare / extinct ; |
| **4** | gene / allele, for blue, pigment / receptors, not passed on ; |
| **5** | water has less effect on red fish ; |
| **6** | number of red fish increase ; |
| **7** | red fish have less competition (because fewer blue fish) ; |
| **8** | red fish extend their range ; |

[max 4]

**A** reference to ‘shallow’ and/or ‘deep’ water fish in place of blue/red if sufficiently qualified

**I** idea of differential predation, effect on plant life, etc.

**[Total: 11]**

STEM | Exam Builder

**9** All commercial breeds of sheep belong to the species *Ovis aries*.

**(a)** Define the term *species*.

.....

.....

.....

.....

..... [2]

The Merino is a breed of sheep that is farmed mainly for its wool. The wool is very thick and is made of lots of very thin hairs.

Fig. 1.1 shows a female Merino sheep with her newborn lamb.



**Fig. 1.1**

**(b)** The presence of hair is a feature that is only found in mammals.

State **two other** features that distinguish mammals from all other vertebrates.

1 .....

2 .....

[2]

STEM

**(c)** Merino sheep in South Africa have high quality wool with very thin hairs.

Breeders in New Zealand have used selective breeding programmes to improve the wool of their sheep to match the quality of South African wool.

Describe the steps that breeders would take to breed sheep that have wool with very thin hairs.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

**(d)** Explain how natural selection differs from selective breeding.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 12]

Natural and artificial selection Click for more variations

| | | | |
|---|---|---|---|
| **9**(a) | (group of) organisms that can reproduce ;<br>to produce fertile offspring ; | **2** | |
| **9**(b) | pinna(e) / external ears ;<br>mammary glands / milk glands / production of milk / lactating / suckling / breast feeding / nipples / AW ;<br>diaphragm ;<br>(three) bones in the middle ear ;<br>(four) different types of teeth / two sets of teeth ;<br>sweat glands ;<br>enucleated red blood cells ;<br>uterus / placenta / navel / AW ;<br>AVP ; | **2** | |
| **9**(c) | select, parent(s) / sheep / AW, with, fine / thin, hairs (in wool)<br>OR<br>use Merino sheep from South Africa and NZ sheep ;<br><br>cross them together / use artificial insemination / IVF / AW ;<br>measure / AW, the hairs in the wool of all the offspring ;<br>select offspring with, fine / thin, hairs (in wool) ;<br>cross / AW, offspring together ;<br>continue / repeat, selection and/or breeding ;<br>over many generations ;<br>AVP ; | **5** | max 4 if no reference to quality of wool |
| **9**(d) | features are, adaptive / adaptations (for environment) ;<br>caused by / AW, the, environment / surroundings ;<br>competition between individuals for (named) resource(s) ;<br>reference to named selective agent(s) ;<br>slow(er) ;<br>increase in fitness ;<br>explained: ability to survive AND reproduce (in natural environment) ;<br>maintains (genetic) variation / less (genetic) variation in selective breeding ;<br>random mating ; | **3** | |

STEM | Exam Builder

**10** **(a)** Sickle cell anaemia is a genetic disorder that is found among people in certain parts of the world.

A sample of blood was taken from a person with sickle cell anaemia and examined with an electron microscope.

Fig. 4.1 shows some of the red blood cells in the sample.

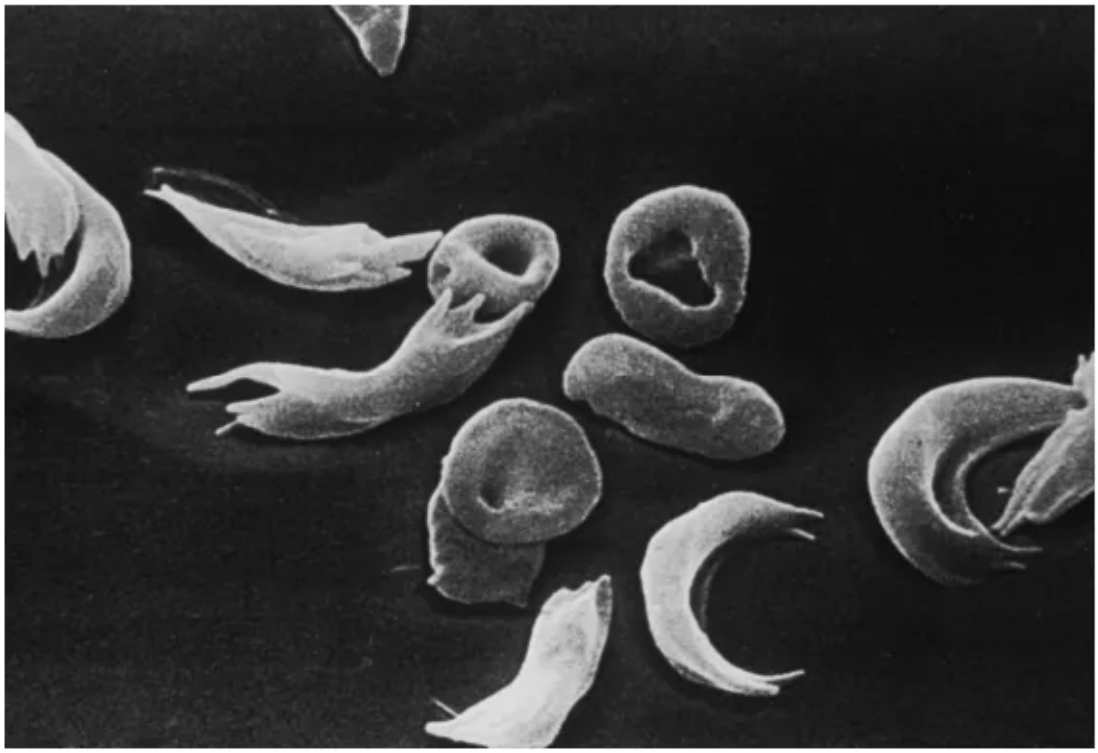


**Fig. 4.1**

Explain the problems that may occur as these cells circulate in the blood system.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

**(b)** The gene for haemoglobin exists in two alternative forms:

$H^A$ codes for the normal form of haemoglobin;
$H^S$ codes for the abnormal form of haemoglobin.

**(i)** State the name for the alternative forms of a gene.

.....

[1]

**(ii)** A child has sickle cell anaemia. The parents do not have this disorder.

Complete the genetic diagram to show how the child inherited the disorder.

**Use the symbols $H^A$ and $H^S$ in your answer.**

| | | | |
|---|---|---|---|
| *parental phenotypes* | normal | × | normal |
| *parental genotypes* | $H^AH^S$ | × | $H^AH^S$ |
| *gametes* | ◯ ◯ | + | ◯ ◯ |

*child's genotype* .....

*child's phenotype* sickle cell anaemia

[2]

**(iii)** The parents are about to have another child.

What is the probability that this child will have sickle cell anaemia?

.....

[1]

STEM | Exam Builder

**(c)** The maps in Fig. 4.2 show the distribution of sickle cell anaemia and malaria in some parts of the world.

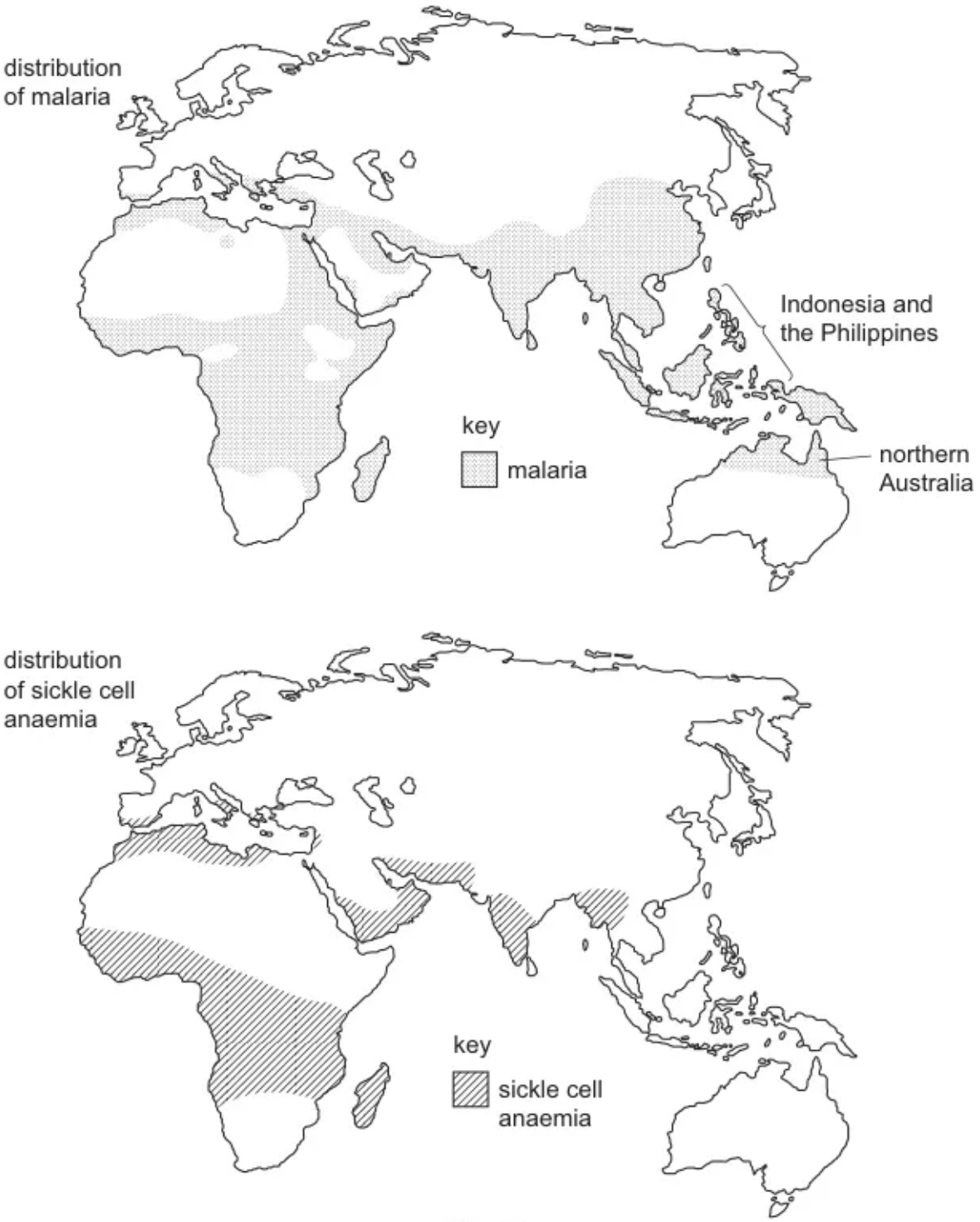



**Fig. 4.2**

STEM EXAMBUILDER

**(i)** Explain why sickle cell anaemia is common in people who live in areas where malaria occurs.

.....

.....

.....

.....

.....

.....

.....

..... [4]

**(ii)** Suggest why sickle cell anaemia is very rare among people who live in Indonesia and northern Australia.

.....

.....

.....

.....

..... [2]

**[Total: 14]**

Variation and mutation Click for more variations

STEM | Exam Builder

| | | | | |
|---|---|---|---|---|
| **10 (a)** | **1**<br>**2**<br>**3**<br>**4**<br>**5**<br>**6**<br>**7**<br>**8**<br>**9** | (red blood cells) get stuck in capillaries / do not flow smoothly / capillaries blocked**;**<br>reduce , supply of, oxygen / nutrients ( to tissues / cells / muscles) **;**<br>reduce , removal of, carbon dioxide / wastes, (from tissues / cells / muscles) **;**<br>ref to respiration (in tissues) **;**<br>cause sickle cell crises **;**<br>pain **;**<br>increased chance of, thrombosis / blood clotting **;**<br>death of tissues / cells **;**<br>AVP **;** | **[max 4]** | **ignore** less haemoglobin<br><br>**A** carries <u>less</u> oxygen / nutrients…<br>**A** carries <u>less</u> carbon dioxide…<br><br>**I** reduced life expectancy |
| **(b) (i)** | allele(s) **;** | | **[1]** | |
| **(ii)** | $H^A$ , $H^S$ + $H^A$ , $H^S$ **;**<br><br>($H^AH^A$ , $H^AH^S$ , $H^AH^S$) <u>$H^SH^S$</u> **;** | | **[2]** | Could be in Punnett square<br>**A** just A and S<br>**A** just S and S |
| **(iii)** | 0.25 / 25 % / ¼ / 1 in 4 **;** | | **[1]** | **I** ratios |

| | | | | |
|---|---|---|---|---|
| **(c) (i)** | **1**<br>**2**<br>**3**<br>**4**<br>**5**<br>**6**<br>**7**<br>**8**<br>**9**<br>**10** | malaria, is severe disease / may be fatal **;**<br>*idea that it is the* selective agent / ref to natural selection **;**<br>$H^AH^A$ / homozygous dominant, susceptible to malaria **;**<br>$H^AH^S$ / heterozygous, resistant **; A** $H^SH^S$ resistant ;<br>$H^AH^S$ survive / $H^AH^A$ more likely to die before have children **;**<br>$H^AH^S$ have children and pass on, the allele / $H^S$ **;**<br>(if $H^AH^S$ x $H^AH^S$) 1 in 4 chance of, $H^SH^S$ / homozygous recessive **;**<br>2 in 4 / ½ , have advantage of resistance to malaria **;**<br>AVP **;** e.g. ref to malarial parasite /<br>AVP **;** e.g. ref to transmission of malaria | **[max 4]** | **A** sickle cell trait / carrier for $H^SH^A$ throughout the answer<br><br>**R** immune |
| **(ii)** | **1**<br>**2**<br>**3**<br>**4**<br>**5**<br>**6**<br>**7**<br>**8**<br>**9** | malaria not very serious / not a severe strain of malaria **;**<br>people have other genetic protection from malaria **;**<br><br>malaria has only recently spread to these areas / no malaria before**;**<br><br>mutation not occurred in populations of these areas **;**<br>people with mutation / have sickle cell allele , have not migrated here **;**<br><br>(majority of) population in Australia has not lived there for long **;**<br>came from areas where no malaria, is / was, present **;**<br><br>AVP **;**<br>AVP **;** | **[max 2]** | E.g. Thalassemia<br><br>**A** mutation described **I** gene, for allele |
| | | | **[Total:14]** | |

STEM | Exam Builder