Chapter 18

Variation and selection

01. 0610_s20_qp_43 Q: 3

The American writer Ernest Hemingway lived on the island of Key West in Florida, USA in the 1930s. During this time he was given a male cat by a sea captain.

The cat had more toes than usual. This inherited condition is called polydactyly. The allele for polydactyly is dominant.

(a) Define the term inheritance.

.....

.....

..... [1]

(b) Fig. 3.1 is part of a pedigree diagram for Hemingway's cats.

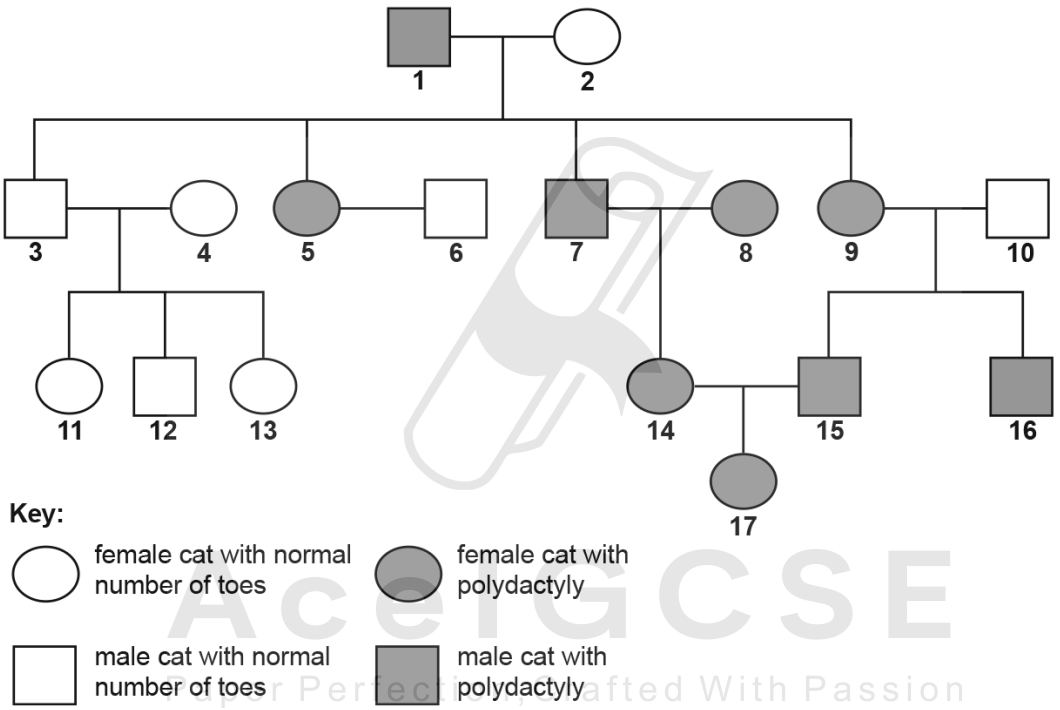


Fig. 3.1

(i) State the genotypes of cats **5**, **6** and **14** in the pedigree diagram in Fig. 3.1.

Use the letters **T** and **t**.

cat **5** .....

cat **6** .....

cat **14** .....

[3]

(ii) Explain why none of the offspring of cats **3** and **4** have inherited polydactyly.

Use the information in Fig. 3.1 in your answer.

.....

.....

..... [1]

(c) Scientists published the results of an investigation into the DNA of cats with and without polydactyly. They compared the base sequence from a particular region of DNA that controls the development of the limbs.

Table 3.1 shows the base sequences.

Table 3.1

cats without polydactyly	AGA CAC AGA AAT GAG
Hemingway's cats with polydactyly	AGA CAC GGA AAT GAG
cats with polydactyly from Oregon and Missouri in the USA	AGA CAC GGA AAT GAG
cats with polydactyly from the UK	AGA CAC AGT AAT GAG

(i) Describe how the base sequences of the cats with polydactyly differ from the base sequence of cats without polydactyly.

.....

.....

.....

.....

..... [2]

(ii) State the name of the process by which base sequences in DNA are changed.

..... [1]

(iii) The base sequences in Table 3.1 provide evidence that indicates which country the male cat given to Hemingway in the 1930s came from.

Suggest which country this cat came from **and** give a reason for your choice.

.....

.....

.....

.....

..... [2]

(d) Fig. 3.2 shows part of a DNA molecule from a chromosome of a cat.

Complete Fig. 3.2 by writing the letters for the base sequence of the other strand of the DNA molecule.

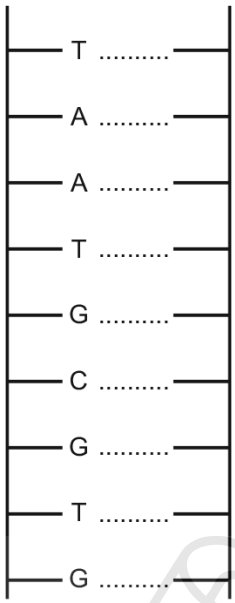


Fig. 3.2

[1]

(e) Explain why polydactyly is an example of discontinuous variation.

.....

.....

.....

.....

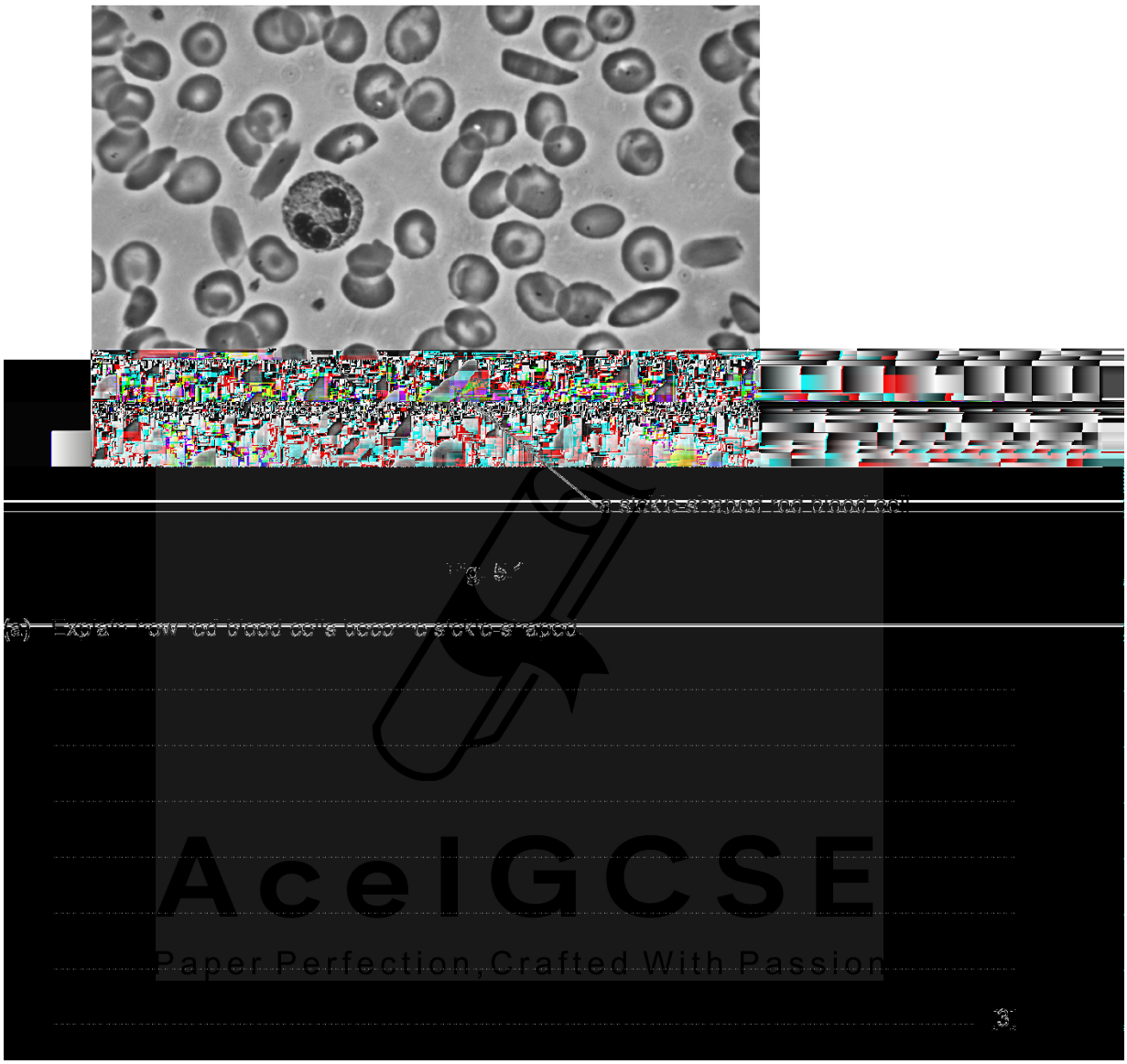
..... [2]

[Total: 13]

02. 0610_s19_qp_43 Q: 5

Sickle-cell anaemia is an inherited disease.

Fig. 5.1 is a photomicrograph of some blood cells from a person who has sickle-cell anaemia.



(b) Some people who have sickle-cell anaemia have parents who do not have sickle-cell anaemia.

Explain how people with sickle-cell anaemia inherit the disease.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) Sickle-cell anaemia is most common in areas of the world where the infectious disease malaria is found.

Some species of the genus *Plasmodium* cause malaria in humans.

(i) Define the term *species*.

.....

.....

.....

.....

..... [2]

(ii) The distribution of sickle-cell anaemia is the result of natural selection.

Explain the distribution of the sickle-cell allele in human populations.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

[Total: 14]

03. 0610_s17_qp_43 Q: 3

Red blood cells in humans are produced from stem cells.

Fig. 3.1 shows how a red blood cell is produced and becomes specialised.

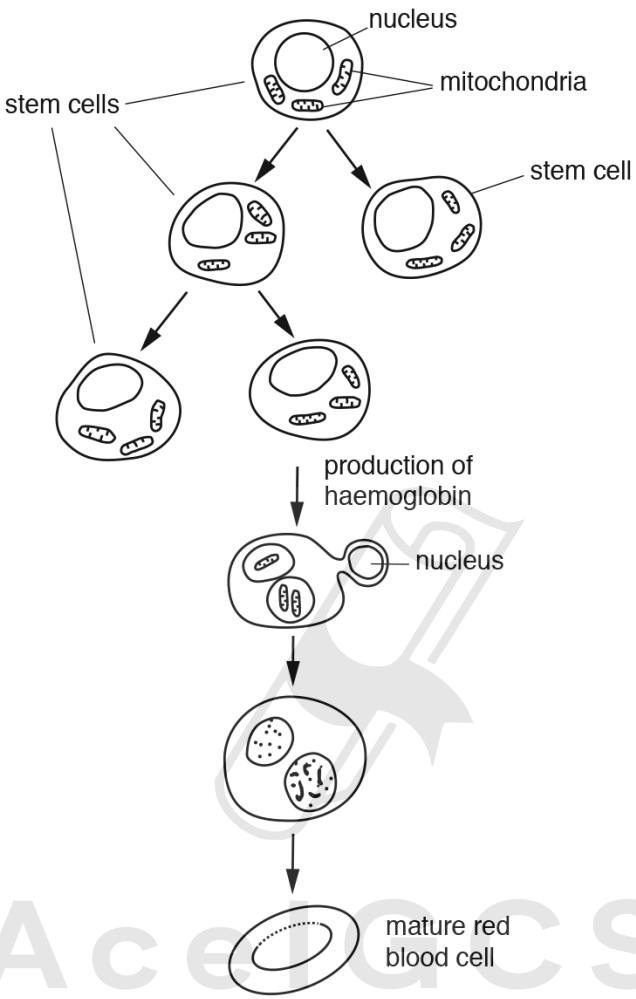


Fig. 3.1

(a) Use the information in Fig. 3.1 to describe how red blood cells are produced and explain how they are adapted to their function.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[6]

(b) Red blood cells are suspended in the liquid part of the blood.

State the name of the liquid part of the blood.

.....[1]

(c) Stem cells are also found under the outer layer of the skin.

Explain why stem cells are found in the skin.

.....

.....

.....

.....[2]

(d) A type of anaemia is caused by a dietary deficiency.

(i) State the nutrient that is deficient in the diet when this type of anaemia occurs.

.....[1]

(ii) State **two** symptoms of anaemia.

1 .....

2 .....

[2]

(e) Some people have sickle cell anaemia.

Describe the cause of this type of anaemia.

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

[Total: 16]

04. 0610_s16_qp_41 Q: 3

Catalase is an enzyme that breaks down hydrogen peroxide inside cells. Red blood cells contain catalase.

Some dogs have an inherited condition in which catalase is not produced. This condition is known as acatalasia and it is caused by a mutation in the gene for catalase.

(a) Define the terms *gene* and *gene mutation*.

gene.....

.....

gene mutation.....

.....

[2]

(b) A geneticist was asked to investigate the inheritance of acatalasia in dogs.

The normal allele is represented by **B** and the mutant allele is represented by **b**.

The geneticist made the diagram in Fig. 3.1 to show the inheritance of acatalasia in a family of dogs. The shaded symbols indicate the dogs with acatalasia.

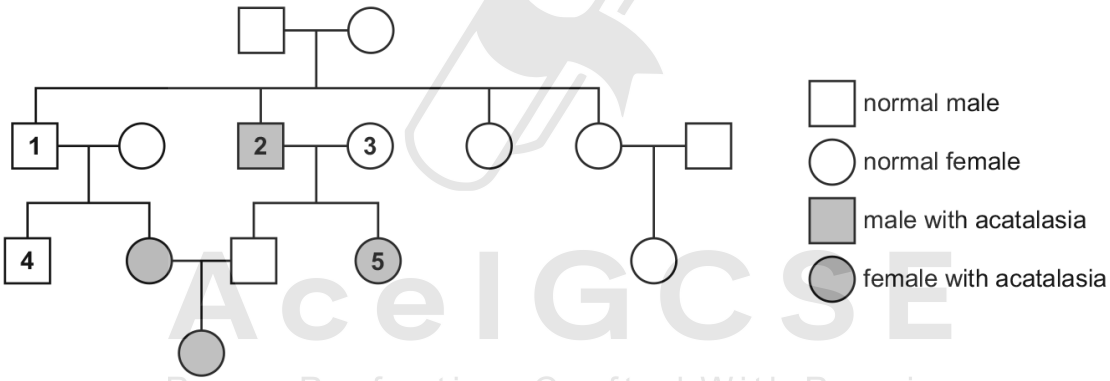


Fig. 3.1

(i) State the genotypes of the dogs identified as **1**, **2** and **3** in Fig. 3.1.

1 .....

2 .....

3 ..... [3]

(ii) The geneticist crossed dog **4** with dog **5**. Approximately half of the offspring had acatalasia and half the offspring did not have acatalasia.

Complete the genetic diagram to show how this is possible.

	dog **4**	dog **5**
parental phenotypes	normal	has acatalasia
parental genotypes	.....	.....
gametes	..... , ...	+ .....

Punnett square

offspring genotypes.....

offspring phenotypes..... [3]

(iii) State the name given to the type of cross that you have completed in **(b)(ii)**.

..... [1]

[Total: 9]

05. 0610_s16_qp_43 Q: 3

(a) Sex in cats is determined in the same way as in humans.

Complete the diagram below to show how sex is determined in cats.

male cat × female cat

female cat (XX)

male cat (.....)	gametes	X	X
	.....		
	.....		

offspring ratio..... [3]

(b) A scientist investigated the inheritance of fur colour in cats.

The gene for coat colour is located on the X chromosome. The gene has two alleles:

- **B** black
- **b** orange.

The X chromosome with the allele for black is represented by $\mathbf{X^B}$.
The X chromosome with the allele for orange is $\mathbf{X^b}$.

A female cat can be a mixture of these colours, described as calico.

Fig. 3.1 shows the inheritance of this condition in a family of cats.

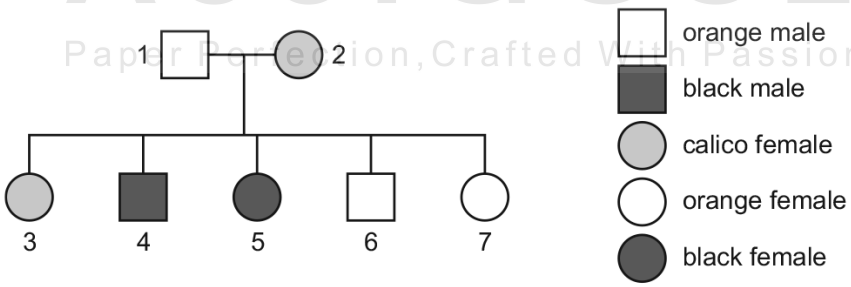


Fig. 3.1

(i) State the genotypes of cats 1, 4, and 5 in Fig. 3.1.

cat 1 .....

cat 4 .....

cat 5 ..... [3]

(ii) Coat colour in cats is an example of discontinuous variation.

Explain why coat colour is an example of discontinuous variation.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 9]

06. 0610_m19_qp_42 Q: 5

Scientists investigated the effect of cuticle thickness on water loss from the leaves of the balsam fir tree, *Abies balsamea*.

The leaves were divided into three groups:

A – thick cuticle
B – medium cuticle
C – thin cuticle

Samples of leaves from each group were weighed. The leaves were placed on a tray in dry air at 20 °C. The samples of leaves were reweighed, at intervals, over 15 hours.

The scientists calculated the mass of each sample of leaves as a percentage of the initial mass.

Fig. 5.1 shows the results.

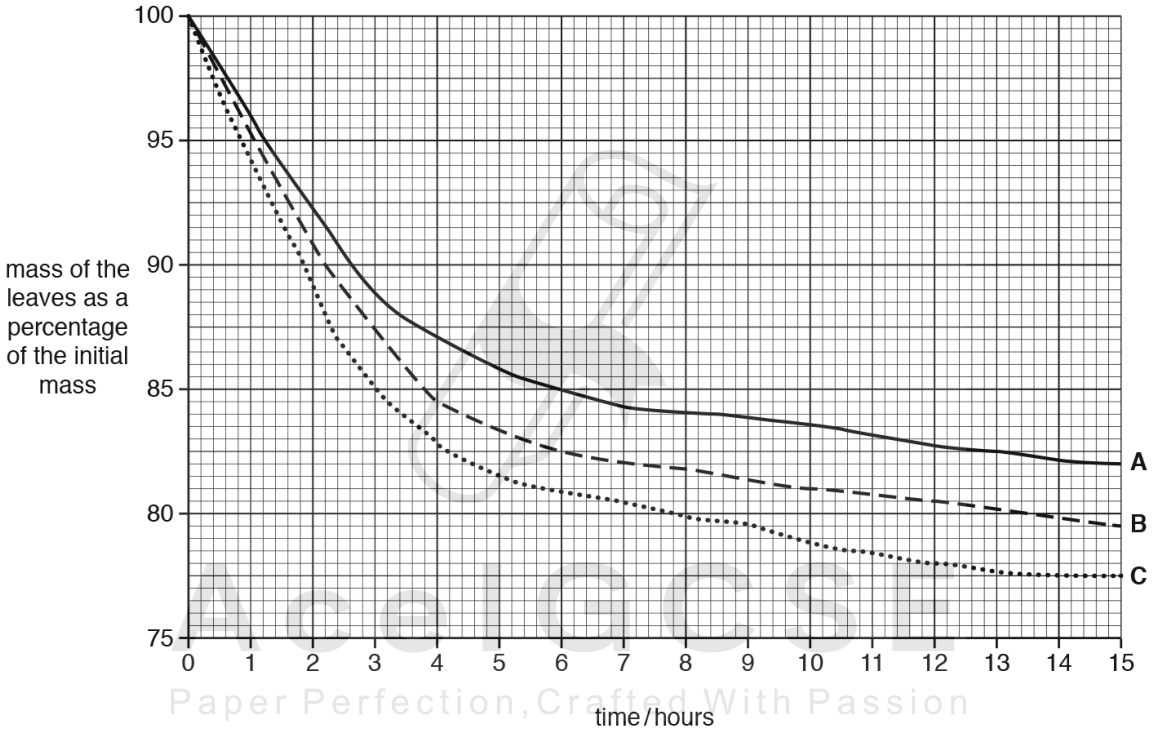


Fig. 5.1

(a) **(i)** Describe **and** explain the results shown in Fig. 5.1.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(ii) The investigation was repeated on a day when the air humidity was higher.

Suggest **and** explain the effect that this would have on the results.

.....

.....

.....

.....

.....

.....

..... [3]

(b) The leaves of pine trees show xerophytic features. Stems and roots also show xerophytic adaptations.

State **one** adaptation of the stem and **one** adaptation of the root in xerophytes.

stem .....

root .....
[2]

(c) Water is one of the raw materials needed for the production of sugars in photosynthesis.

(i) State the name of the other raw material needed for photosynthesis.

..... [1]

(ii) State **three** ways a plant uses the sugars produced in photosynthesis.

1 .....

2 .....

3 .....

[3]

[Total: 14]

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.

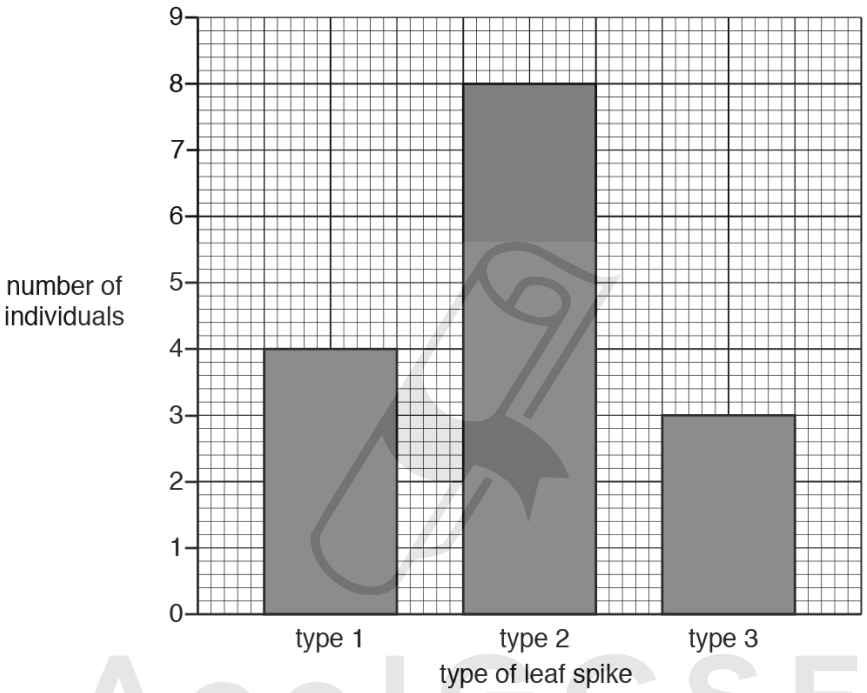


Fig. 5.1

(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]

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

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

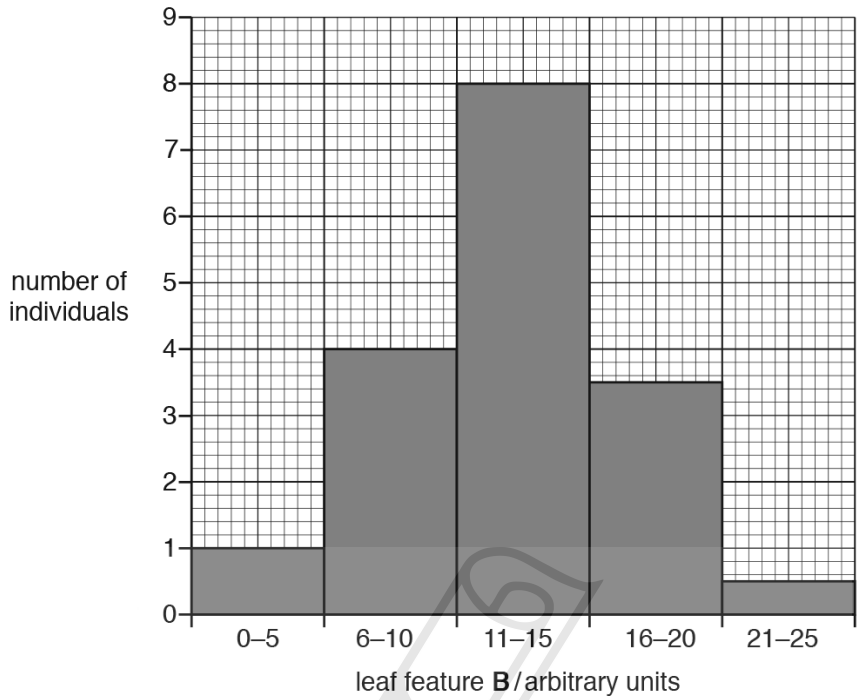


Fig. 5.2

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

1 .....

2 .....

[2]

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

The results are shown in Fig. 5.3.

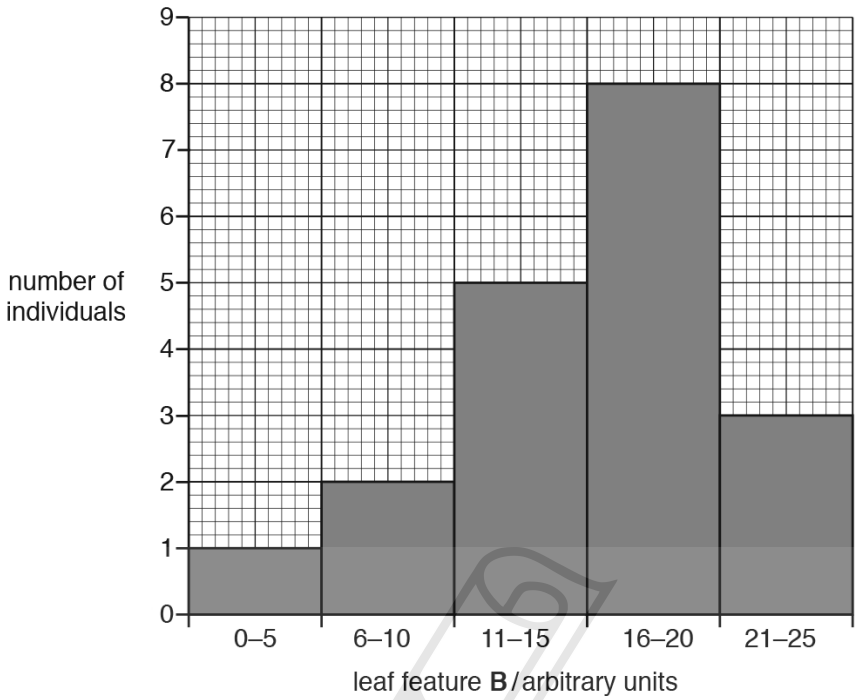


Fig. 5.3

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

.....

.....[1]

[Total: 7]

08. 0610_w16_qp_42 Q: 4

Hydrophytes are plants that show many adaptive features for life in aquatic habitats.

Fig. 4.1 shows several species of hydrophyte growing in freshwater.

Fig. 4.1

A student investigated the density of stomata on the leaves of two different species of freshwater hydrophyte.

Table 4.1 shows the results.

Table 4.1

species	location of leaves	mean stomatal density / number per mm^2	
		upper epidermis	lower epidermis
Brazilian waterweed, *Egeria densa*	under the surface of the water	0	0
water lily, *Nuphar lutea*	on the surface of the water	420	0

(a) Name the epidermal cells that control the size of stomata.

..... [1]

(b) Suggest reasons for the difference between the results for the two species.

.....

.....

.....

.....

..... [2]

(c) Fig. 4.2 shows a section through the leaf of a water lily.

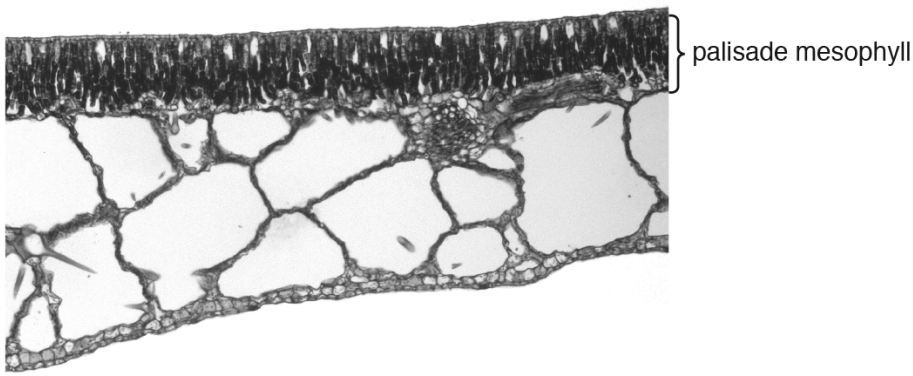


Fig. 4.2

(i) State why the palisade mesophyll is a tissue.

.....

..... [1]

(ii) Name **two** other tissues that are present in the leaf in Fig. 4.2.

1 .....

2 .....

[2]

(d) The large air spaces are an adaptation of water lily leaves. Suggest why.

.....

.....

.....

.....

..... [2]

(e) Hydrophytes are adapted to aquatic habitats.

State the name used for plants that are adapted to dry habitats.

..... [1]

(f) Explain what is meant by the term *adaptive feature*.

.....

.....

.....

.....

..... [2]

[Total: 11]

09. 0610_s19_qp_41 Q: 1

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]

(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]

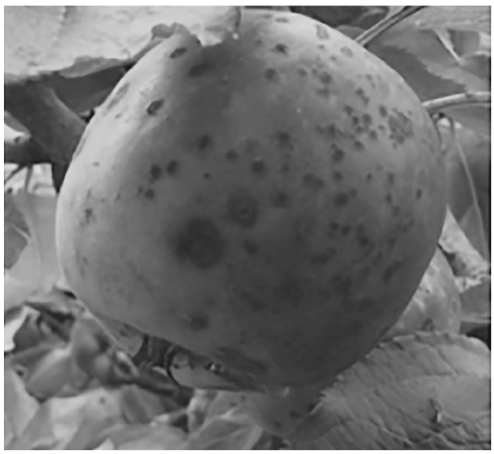
[Total: 12]

10. 0610_w17_qp_43 Q: 3

Apple scab is a disease that infects apple trees.

Fig. 3.1 shows apples from uninfected and infected apple trees.

uninfected apple tree



infected apple tree

Fig. 3.1

There is a gene that determines whether or not apple trees are resistant to apple scab disease.

There are two alleles for this gene:

- disease-resistant, **R**
- not disease-resistant, **r**

(a) (i) Complete the sentence.

Genes and alleles are made of ..... . [1]

(ii) A farmer wanted to do a test cross to identify the genotype of disease-resistant apple trees. This would tell him whether his trees were either homozygous dominant or heterozygous.

Determine the phenotypes of the offspring if the unknown parent apple tree was heterozygous.

Complete the genetic diagram:

parental phenotypes	disease-resistant	×	not disease-resistant
parental genotypes	.....	×	.....
gametes	..... , ...	×	..... , ...

offspring genotype .....

offspring phenotype .....

[5]

(b) The farmer wanted to breed disease-resistant apple trees.

(i) He decided **not** to use heterozygous disease-resistant apple trees in his selective breeding programme.

Explain why.

.....

.....

.....

.....

.....

.....

.....[2]

(ii) The farmer wanted to be sure that only the selected disease-resistant apple trees would reproduce.

Suggest what the farmer could do to ensure that only the selected apple trees were pollinated.

.....

.....

.....[1]

(iii) Describe how artificial selection differs from natural selection.

.....

.....

.....

.....

.....[2]

[Total: 11]

01. 0610_s20_MS_43 Q: 3

(a)	transmission of genetic information from generation to generation ;	1
(b)(i)	**Tt** ; **tt** ; **TT** / **Tt** ;	3
(b)(ii)	cats **3** and **4** are homozygous recessive / do not have the allele for polydactyly ;	1
(c)(i)	*any two from:* cats with normal number of toes have AGA for bases 7, 8 and 9 ; cats with polydactyly have GGA or AGT ; bases 7 and 9 are different / base 7 is G not A in the USA cats / base 9 is T not A in the UK cats ;	2
(c)(ii)	mutation ;	1
(c)(iii)	origin of the cat was USA ; base sequence is the same as the other cats from the USA / they have the same, mutation/base sequence, as the Oregon and Missouri cats ;	2
(d)	T A A T A T T A G C C G G C T A G C ;	1
(e)	distinct, phenotypes / categories ; no intermediates / phenotypes not on a continuous scale ;	2

02. 0610_s19_MS_43 Q: 5

	Answer	Mark	Partial Marks
(a)	caused by a mutation ; change in, DNA / base sequence ; of gene for haemoglobin ; (causes) a different sequence of amino acids ; (so) abnormal haemoglobin produced ; AVP ;	3	
(b)	both parents carry the, recessive allele / allele for (sickle cell) anaemia ; both parents are heterozygous ; half the gametes of both parents have the recessive allele ; people / children, who are homozygous recessive have (sickle cell) anaemia ; there is a, 0.5 □ 0.5 / 0.25, chance of, being homozygous recessive / having (sickle cell) anaemia ;	4	
(c)(i)	(group of) organisms that can reproduce ; to produce fertile offspring ;	2	
(c)(ii)	people with sickle cell anaemia / heterozygotes / carriers / are resistant to, malaria / AW ; people with (homozygous) sickle cell anaemia are, less likely to survive / die of sickle cell disease ; people who are heterozygous / have one copy of the sickle cell allele, are more likely to survive / have selective advantage ; *idea that* they are more likely to breed ; pass on allele for sickle cell ; so increase in frequency of sickle cell allele (in population) ; selective advantage for sickle cell only exists where, (mosquitoes carrying) malaria are present ; AVP ; ref. to evolution / adaptation to (local) conditions	5	

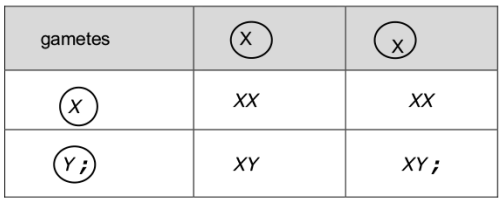
03. 0610_s17_MS_43 Q: 3

	Answer	Mark	Partial Marks
(a)	*description* 1 (stem) cells divide ; 2 by mitosis ; 3 to form, daughter / genetically identical, cells ; 4 nucleus buds off / AW ; 5 digested / broken down, mitochondria ; 6 only one of stem cells specialises / others continue to be stem cells ; *adaptations* 7 haemoglobin made prior to, mitochondria / nucleus removed / maturation ; 8 (loss of structures) gives space for, oxygen transport / haemoglobin ; 9 haemoglobin, transports / AW, oxygen ; 10 biconcave shape / described ; 11 large surface area (to volume ratio) ; 12 for diffusion of oxygen / gas(es) ; 13 AVP ;	6	**MP1 I** reproduce **MP4 A** no nucleus (in mature red blood cell) **MP5 A** no mitochondria (in mature red blood cell) **MP7** must be in correct place in sequence of events **MP8 A** volume for space, **I** area **MP12 I** ref to gas exchange
(b)	plasma ;	1	
(c)	replacement / repair / wound healing ; cells die / are, rubbed off / exfoliated / AW ; growth ;	2	
(d)(i)	iron / Fe / Fe^{2+} / Fe^{3+} ;	1	**R** ion unqualified **A** vitamin B_{12}
(d)(ii)	tired / lethargic / 'no energy' / weakness / AW ; shortness of breath ; chest pain ; fast heartbeat ; frequent infections ; headache / dizziness / light-headedness ; cold, hands / feet ; inflammation / soreness, of tongue ; brittle nails ; unusual cravings for non-nutritive substances, such as ice, dirt or starch ; poor appetite ; tingling or crawling feeling in legs ;	2	**A** pale skin
(e)	1 mutation ; 2 change in, base sequence / DNA ; 3 in gene / allele, for haemoglobin ; 4 inherit the allele (for sickle cell anaemia / mutated haemoglobin / Hb^S) ; 5 having the recessive allele(s) / being, homozygous recessive / Hb^SHb^S / heterozygous / Hb^SHb^A ; 6 produce, abnormal / AW, haemoglobin ; 7 red blood cells have, sickle shape / described ; 8 AVP ;	4	**I** references to malaria **MP4 A** allele passed down from, a carrier / parent with sickle-cell anaemia

04. 0610_s16_MS_41 Q: 3

	Answer	Mark	Partial Marks
(a)	*gene* a length of DNA that codes for a protein ; *gene mutation* a change in base sequence of DNA ;	[2]	**R** chromosome / molecule of / genome
(b) (i)	1 **Bb** ; 2 **bb** ; 3 **Bb** ;	[3]	
(ii)	(Bb x bb) **B** , **b** + **b** , (**b**) ; *offspring genotypes* **Bb** and **bb** ; **A** heterozygous and homozygous recessive *offspring phenotypes* normal / carrier and acatalasia ;	[3]	male gametes: **B**, **b** female gametes: **b**, (**b**) **Bb**, **bb** (**Bb**), (**bb**)
(iii)	test (cross) ;	[1]	
		[Total: 9]	

05. 0610_s16_MS_43 Q: 3

	Answer	Mark	Partial Marks
(a)	 offspring ratio = 1:1 / 50:50 / 50% male, 50% female / 2:2 ;	[3]	
(b) (i)	**cat 1** X^bY ; **cat 4** X^BY ; **cat 5** X^BX^B ;	[3]	
(ii)	distinct, phenotypes / coat colours / categories ; no (continuous) range of colour / AW ; controlled by genes ; not affected by the, environment / AW / named example ;	[3]	**A** only orange, black and calico **A** inherited
		[Total: 9]	

---

06. 0610_m19_MS_42 Q: 5

	Answer	Mark	Partial Marks
(a)(i)	**1** leaf **A** / thick cuticle, lost the least mass / water ; **2** leaf **C** / thin cuticle, lost the most mass / water ; **3** leaf **B** / medium cuticle, lost more mass or water than **A** / less mass or water than **C** ; **4** loss of mass is due to the loss of water ; **5** the thicker the cuticle the, less water / mass, lost ; **6** loss of, mass / water, fastest initially (then slows) ; **7** ref. to transpiration / (reduced) evaporation ; **8** data manipulation with ref. to mass ; e.g. calculation of loss	5	
(a)(ii)	less, water / mass, loss (from leaves **A**, **B** and **C**) ; *idea of* the same pattern of results as the first experiment ; reduced transpiration ; increased water (concentration) in the air ; ref. to a smaller concentration gradient ; less diffusion of water vapour ;	3	
(b)	*stem* – swollen / AW ; *root* – extensive / widespread / shallow (root system) / AW ;	2	**A** deep / branched
(c)(i)	carbon dioxide ;	1	
(c)(ii)	respiration ; starch ; cellulose ; chlorophyll ; sucrose ; nectar ; amino acids / protein ; fats / oils ; nucleic acids / DNA / RNA ; growth of (any named part) membrane, cell wall, cytoplasm ;	3	

---

07. 0610_w18_MS_43 Q: 5

	Answer	Mark	Partial Marks
(a)	dry / AW ;	1	
(b)(i)	discontinuous ;	1	
(b)(ii)	limited number of phenotypes / three categories ; no intermediates / discrete / separate categories / AW ; caused by genes only ; bar chart (has gaps) ;	2	
(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
(d)	measured different leaves ; change in (named) environmental (feature) ; adapted to environment ; leaves / plant, have, grown / older ; AVP ;	1	**A** mutation

---

08. 0610_w16_MS_42 Q: 4

	Answer	Mark	Partial Marks
(a)	guard cells;	1	
(b)	Brazilian waterweed / *E. densa*, exchanges (dissolved) (named) gas(es) with the water; Water lily / *N. lutea*, exchanges (named) gas(es) with the air;	2	
(c)(i)	(group of) similar cells that, work together / carry out a shared (named) function;	1	
(c)(ii)	xylem; phloem; epidermis; spongy mesophyll;	2	**R** cuticle **A** aerenchyma
(d)	air spaces in the leaf for, buoyancy / AW; *max 1 for any of the following* leaves are closer to the light / 'gets more light' to absorb more light; for more photosynthesis; to exchange gases with the, air / atmosphere;	2	**1 + 1** **A** floating **I** being on the surface
(e)	xerophyte(s);	1	
(f)	inherited feature ; feature helps an organism survive and reproduce; in its, habitat / environment; (a named) adaptive feature increases organism's fitness;	2	
		Total: 11	

---

09. 0610_s19_MS_41 Q: 1

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

10. 0610_w17_MS_43 Q: 3

	Answer	Mark	Partial Marks
(a)(i)	DNA ;	1	**A** correct elements **I** RNA
(a)(ii)	*parental phenotypes* resistant x not disease-resistant *parental genotypes* Rr ; x rr ; *gametes* R r x r (r) ; *offspring genotype* Rr and rr ; *offspring phenotype* resistant and not resistant / AW ;	5	**ecf** from previous line above throughout
(b)(i)	heterozygous, plant / parent, carry the not-resistant / r, allele ; some offspring would be, not-resistant / rr / homozygous recessive ; using heterozygotes results in profit loss / AW ;	2	**A** homozygous dominant = no r allele / only R **A** therefore all offspring are disease-resistant
(b)(ii)	paint pollen onto selected trees / AW ; isolate plants / cover flowers, of unselected trees ; identify not disease resistant trees ; AVP ; remove not-resistant trees	1	**A** artificial pollination
(b)(iii)	human choice (rather than environmental pressures) / AW ; less, diversity / variation ; faster change ; AVP ; e.g. mating is not random	2	**A** named features for human use **A** reduced fitness (of species)