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

Surname	Other names

Centre number | | | | | |

Candidate number | | | | |

STEM | Exam Builder

Chromosomes, genes and proteins

Time allowed: 1 hour 30 minutes

Subject code **0610**

Biology

Questions from Paper 3 and Paper 4

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

Total marks

/ 91

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 91 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.

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

1 **(a)** Fig. 10.1 shows the results of crossing a plant with red flowers with a plant with white flowers.

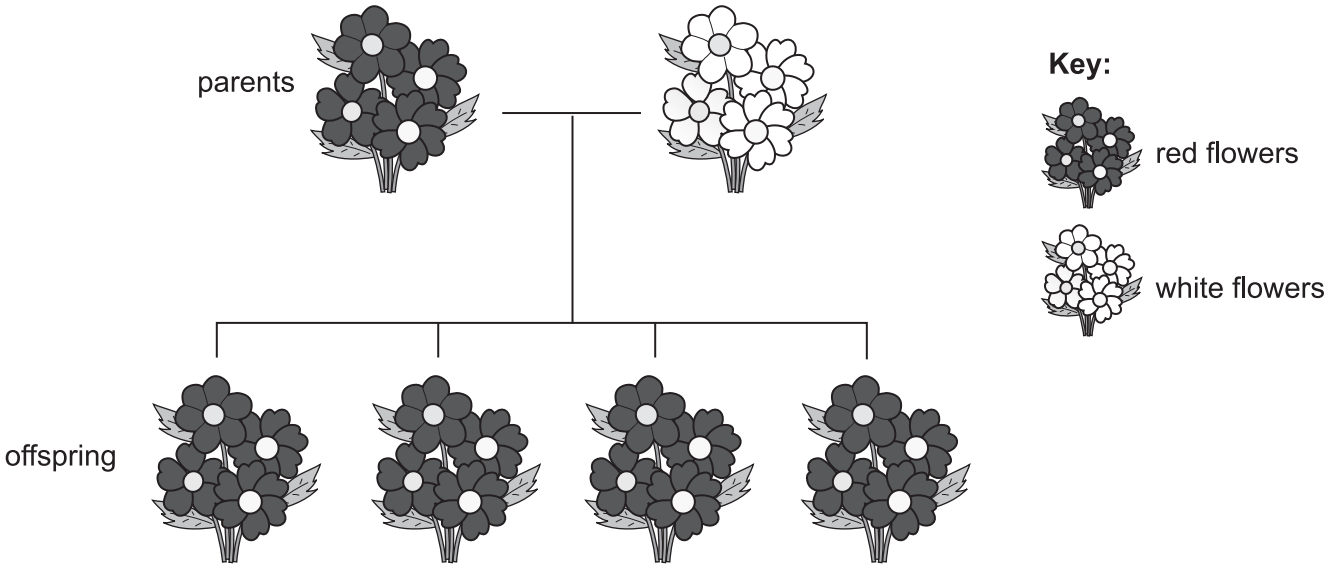


Fig. 10.1

Both of the parent plants were homozygous for flower colour.

All of their offspring had red flowers.

(i) State what is meant by the term homozygous.

.....

.....

..... [1]

(ii) The gene controlling flower colour in this plant species has two alleles:

- **R** is dominant and represents the allele for red flowers
- **r** is recessive and represents the allele for white flowers.

Describe the evidence shown in Fig. 10.1 that supports the fact that **R** is the dominant allele for flower colour in this species of plant.

.....

.....

..... [1]

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(b) Another plant with red flowers was crossed with a plant with white flowers.

Some of the offspring plants from this cross had red flowers and some of the offspring plants had white flowers.

Complete the genetic diagram to show the results of this cross.

	red-flowered plant	X	white-flowered plant
parental genotypes	.....	X	.....

parental gametes ....

offspring genotypes .....

offspring phenotypes .....

[5]

[Total: 7]

Monohybrid inheritance Click for more variations

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1(a)(i)	has two identical alleles (for a particular gene)**;**	**1**	
1(a)(ii)	(one of the parent plants is white but) all of the offspring have red flowers **;**	**1**	
1(b)	*parental genotypes: (red flower)* **Rr ;** (white flower) **rr ;** *parental gametes:* **R**, **r** and **r**, (**r**) **;** *offspring genotypes:* **Rr** and **rr ;** *offspring phenotypes:* red and white **;**	**5**	

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2 Fig. 4.1 shows the sex chromosomes in a fertilised human egg.

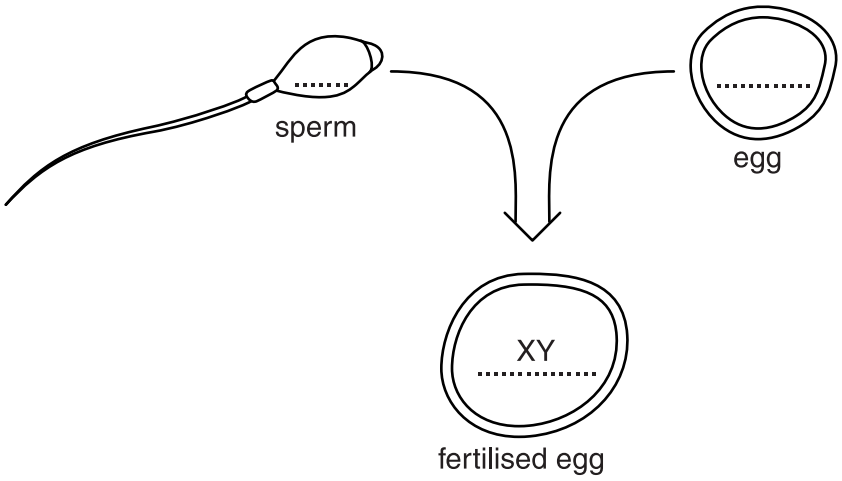


Fig. 4.1

(a) **(i)** Complete the diagram to show the sex chromosomes in the sperm and the egg. [1]

(ii) State the biological name for a fertilised egg.

.....[1]

(b) The fertilised egg develops into a baby.

Explain why there are approximately equal numbers of male and female babies in humans.

.....

.....

.....

.....

.....

.....[3]

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(c) **(i)** Identical twins are formed when one sperm fertilises one egg, which then splits into two. Each of these then develops into an embryo.

Compare the alleles present in a pair of identical twins.

.....

.....[1]

(ii) Tony and Edward are identical twins.



Tony Edward

Table 4.1 gives some information about some characteristics of Tony and Edward.

Table 4.1

characteristic	Tony	Edward
sex	male	male
height/cm	161	162
weight/kg	55	58
skin colour	pale	tanned
hair style	short hair	long hair
blood group	A	A

State the **two** characteristics from Table 4.1 that are **only** controlled by genetic information.

....[2]

[Total: 8]

Chromosomes, genes and protein synthesis Click for more variations

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2 **(a) (i)**	Y in sperm and X in egg;	**1**	both correct for 1 mark
(ii)	zygote;	**1**	
(b)	male is XY and female is XX; idea of random assortment (at meiosis); sperm / male gametes are X or Y and eggs / female gametes are all X; idea of equal chance of an X or Y sperm fertilising an egg / random fertilisation;;	**max 3**	**A** information given in Punnett square
(c) (i)	alleles must be identical / the same;	**1**	
(ii)	sex / gender; blood group;	**2**	
		[Total: 8]	

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3 Fig. 7.1 shows a goat with white fur.



Fig. 7.1

Fur colour is inherited in goats.

- The allele for white fur is represented by **A**.
- The allele for black fur is represented by **a**.
- Each goat is identified by the numbers **1** to **8** in Fig. 7.2.

Fig. 7.2 shows a diagram of the inheritance of fur colour in a herd of goats.

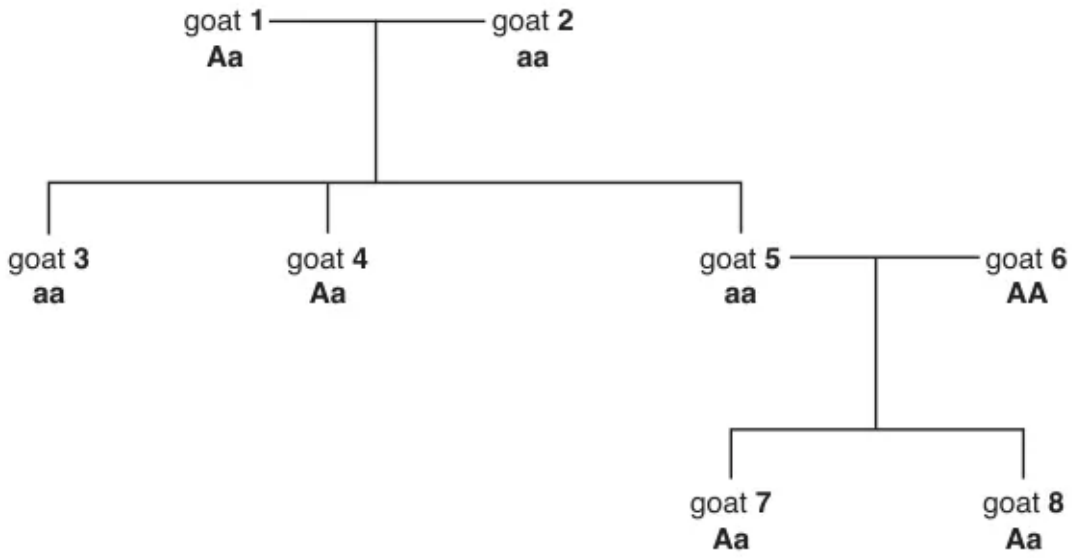


Fig. 7.2

STEM

(a) Use Fig. 7.2 to answer these questions.

(i) State how many goats have white fur.

.....[1]

(ii) State the phenotype of goat **5**.

.....[1]

(iii) Draw circles around **two** terms that can be used to describe the **genotype** of goat **6**.

black	**dominant**	**heterozygous**
homozygous	**recessive**	**white**

[2]

(b) State the name of the type of variation shown by fur colour in these goats.

.....[1]

(c) A farmer identified two goats to breed together.

- The genotype of the male goat is **Aa**.
- The genotype of the female goat is **Aa**.

Complete the genetic diagram and the phenotypic ratio for this cross.

		male	
female			

phenotypic ratio ..... white : ..... black

[3]

(d) Describe the process a farmer could use to breed a herd of white goats.

.....

.....

.....

.....

.....

.....

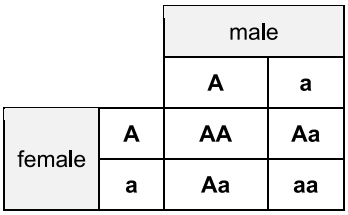
.....[3]

[Total: 11]

Monohybrid inheritance Click for more variations

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3(a)(i)	five / 5 ;	**1**	
3(a)(ii)	black (fur / coat) ;	**1**	
3(a)(iii)	homozygous circled ; dominant circled ;	**2**	
3(b)	discontinuous ;	**1**	

3(c)(i)	(male and female gametes) **A** and **a** ; (offspring) **AA**, **Aa**, **Aa** and **aa** ; (phenotypic ratio) 3 (white) : 1 (black) ;	**3**	ecf from the step before 
3(d)	use selective breeding ; breed / cross / mate, two white goats ; select offspring with white coats and breed again / do not breed the offspring with black coats **or** remove black goats ; *idea of* (breeding) over many generations ; correct ref. to homozygous dominant ;	**3**	

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4 Some students used beetles to investigate inheritance.

One group of students decided to breed a beetle which had long antennae with a beetle which had short antennae. Fig. 6.1 shows the beetles they used.

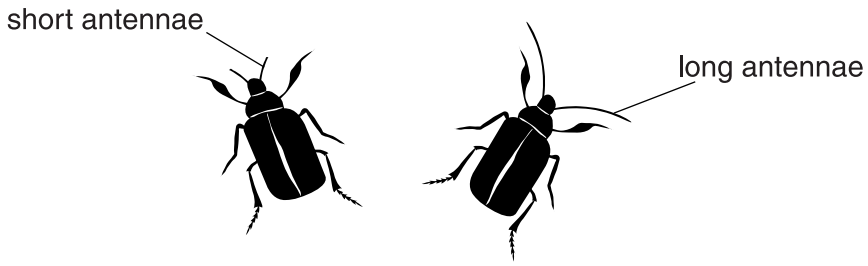


Fig. 6.1

All of the offspring from this **first** breeding experiment had long antennae.

(a) The students decided that the beetles they had used must have been **pure-breeding** for the lengths of their antennae.

Explain the term *pure-breeding*.

.....

.....[1]

(b) The students used the results of their breeding experiment to make conclusions about the *alleles* for long and short antennae.

(i) State what is meant by an *allele*.

.....[1]

(ii) What conclusions can be made about the alleles for long and short antennae?

long antennae .....

short antennae .....[2]

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(c) The students decided to breed two of the offspring (with long antennae) from their first breeding experiment with each other.

There were 20 offspring from this **second** breeding experiment.
15 of these beetles have long antennae.

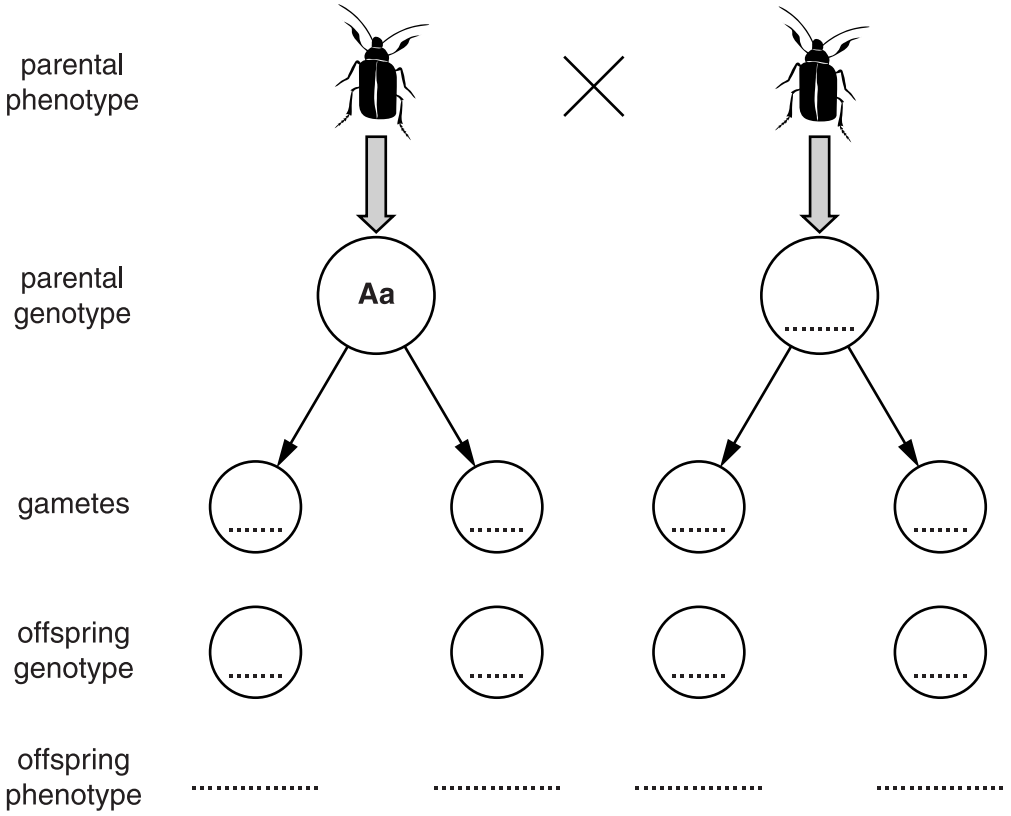
(i) State the number of beetles which have short antennae. .....[1]

(ii) Calculate the ratio of long antennae to short antennae. .....[1]

(d) Fig. 6.2 shows part of the genetic diagram for the **second** breeding experiment.

Complete Fig. 6.2.

- Use **A** to represent the allele for long antennae.
- Use **a** to represent the allele for short antennae.



[4]

Fig. 6.2

(e) In **another** investigation, a beetle with long antennae and a beetle with short antennae were bred together several times.

A total of 60 offspring were produced.

There were 31 with long antennae and 29 with short antennae.

Deduce the genotype of the parent that had long antennae.

.....[1]

[Total: 11]

Monohybrid inheritance Click for more variations

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4 **(a)**	have 2 alleles which are, the same / identical / homozygous;	[1]	
(b) (i)	(two or more) alternative / different forms of a gene / AW;	[1]	
(ii)	long is dominant / expresses itself in heterozygote AW; short is recessive / hidden in heterozygote AW;	[2]	
(c) (i)	5;	[1]	
(ii)	3:1;	[1]	
(d)	Aa; A and a X A and a; (either order) AA Aa Aa aa; (any order so long as correct re “lines”) long long long short; (order must match genotypes)	[4]	allow ecf if a mistake is made, but each line must correspond to the previous one
(e)	Aa / heterozygote;	[1]	
		[Total: 11]	

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5 There are four blood groups in the ABO system in humans: A, B, AB and O.

The gene that determines blood group has three alleles: I^A, I^B and I^o.

(a) Parents with the genotypes I^AI^o and I^BI^o are planning to have more children.

Complete the genetic diagram to determine the probability that the next child will have blood group O.

parental blood groups A B

parental genotypes I^AI^o I^BI^o

Punnett square

phenotypes of the children .....

probability that the child will have blood group O .....

[4]

(b) Explain why the ABO blood group system is an example of co-dominance.

.....

.....

.....

.....

..... [2]

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(c) Fig. 6.1 shows the percentages of the global population with the four different blood groups in the ABO system.

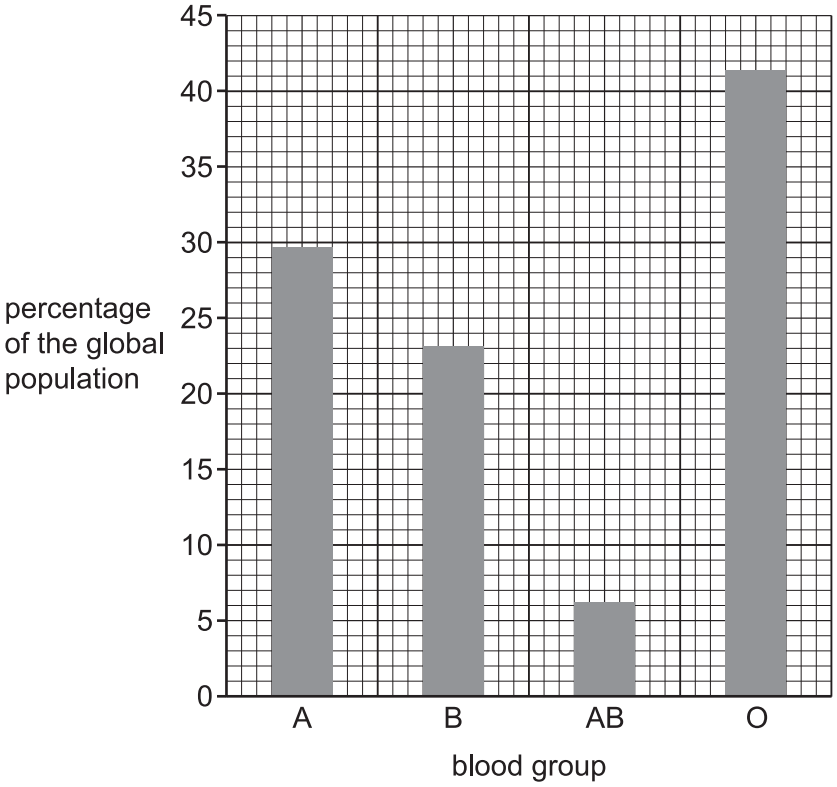


Fig. 6.1

With reference to Fig. 6.1, explain why the ABO blood group system is an example of discontinuous variation.

.....

.....

.....

.....

.....

..... [2]

[Total: 8]

Monohybrid inheritance Click for more variations

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5(a)	<table><tr><td></td><td>I^A</td><td>I^O</td></tr><tr><td>I^B</td><td>I^AI^B</td><td>I^BI^O</td></tr><tr><td>I^O</td><td>I^AI^O</td><td>I^OI^O</td></tr></table> ;; *phenotypes of the children:* **AB**, **B**, **A**, **O** ; *probability…blood group O:* 0.25 / 25% / 1 in 4 ;	**4**	one mark for four correct gametes in Punnett square one mark for four correct offspring genotypes in Punnett square
5(b)	both / two, alleles are expressed in, heterozygote / phenotype / AW ; ref. to, blood group **AB** / I^AI^B ;	**2**	
5c)	*any two from:* phenotype is determined only by a gene ; no effect of environment on phenotype ; only, four / limited number of, phenotypes / (blood) groups / categories ; no intermediates between categories ;	**2**	

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6 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.

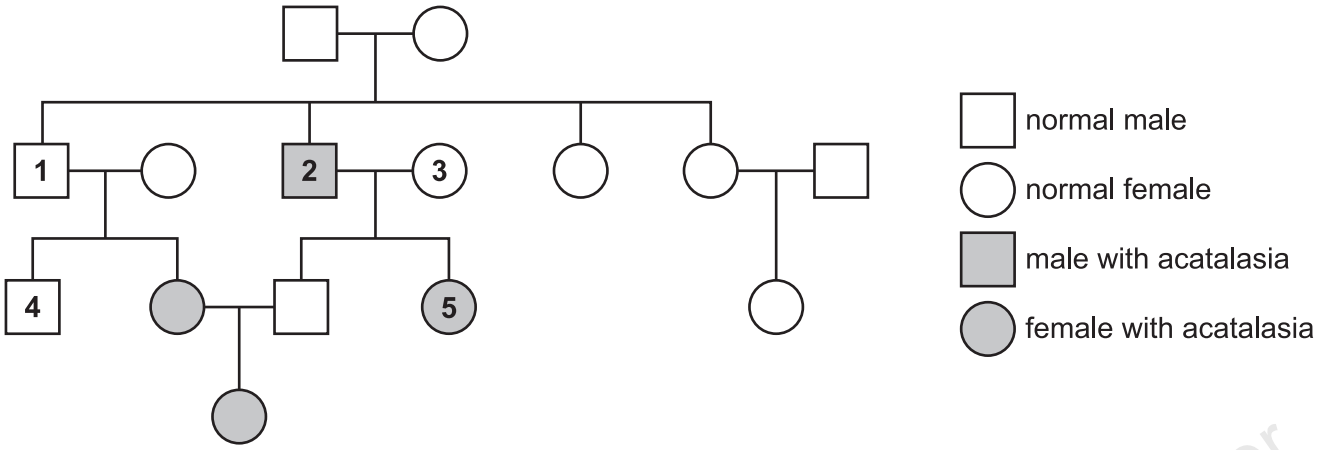


Fig. 3.1

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

1 .....

2 .....

3 ..... [3]

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(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]

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6 (a)	*gene* a length of DNA that codes for a protein **;** *gene mutation* a change in <u>base</u> 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]	<table><tr><td colspan="2"></td><td colspan="2">male gametes</td></tr><tr><td colspan="2"></td><td>**B**</td><td>**b**</td></tr><tr><td rowspan="2">female gametes</td><td>**b**</td><td>**Bb**</td><td>**bb**</td></tr><tr><td>(**b**)</td><td>(**Bb**)</td><td>(**bb**)</td></tr></table>
(iii)	test (cross) **;**	[1]	
		[Total: 9]	

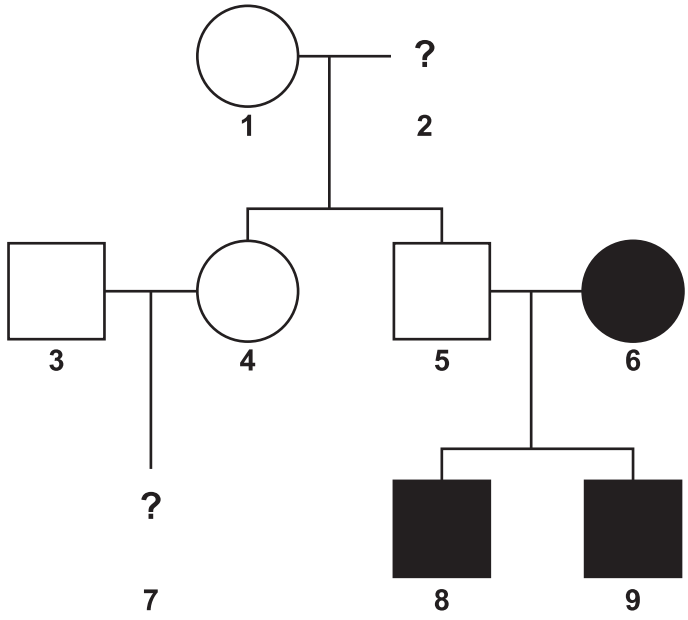
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7 Feather colour in some breeds of chicken is an example of codominance in birds.

In this example, a chicken with white feathers and a chicken with black feathers can breed to produce offspring that have white feathers and black feathers.

The allele for black feathers is F^B and the allele for white feathers is F^W.

Fig. 5.1 is a pedigree diagram of a family of chickens.



Key

Circles represent females and squares represent males.

chickens with black feathers only

chickens with white feathers only

chickens with both black feathers and white feathers

Fig. 5.1

(a) State the type of variation that is caused by genes only.

..... [1]

(b) State **all** the possible genotypes of chicken **2** and chicken **7** in Fig. 5.1.

chicken **2** .....

chicken **7** .....

[2]

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(c) Complete the genetic diagram to show the results of a cross between chicken **5** and chicken **6** in Fig. 5.1.

	chicken **5**		chicken **6**
parental phenotypes	.....	×	.....
parental genotypes	.....	×	.....
gametes	..... , ...		..... , ...

offspring genotypes .....

expected offspring phenotype percentage .....

[5]

(d) State **one** example of codominance in humans.

..... [1]

[Total: 9]

Monohybrid inheritance Click for more variations

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

7(a)	discontinuous **;**	**1**	
7(b)	*chicken 2* – F^BF^B and F^BF^W **;** *chicken 7* – F^WF^W and F^BF^W and F^BF^B **;**	**2**	
7(c)	*phenotypes: (**5**)*(male) black and white (feathers) × *(**6**)(*female) black (feathers) **;** *parental genotypes:* F^BF^W × F^BF^B **;** *gametes:* F^B , F^W F^B , F^B **;** *offspring genotypes:* F^BF^W, (F^BF^W) and F^BF^B, (F^BF^B) **;** *offspring phenotype percentage:* 50(%) black and white and 50(%) black **;**	**5**	ecf from previous step
7(d)	(ABO) blood group / AVP **;**	**1**	

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8 The gene for red-green colour vision is on the **X** chromosome.

There are two alleles for this gene:

- The allele for normal colour vision is represented by the letter **B**.
- The allele for red-green colour blindness is represented by the letter **b**.

Fig. 5.1 shows a pedigree chart for a family in which some of the members are red-green colour-blind.

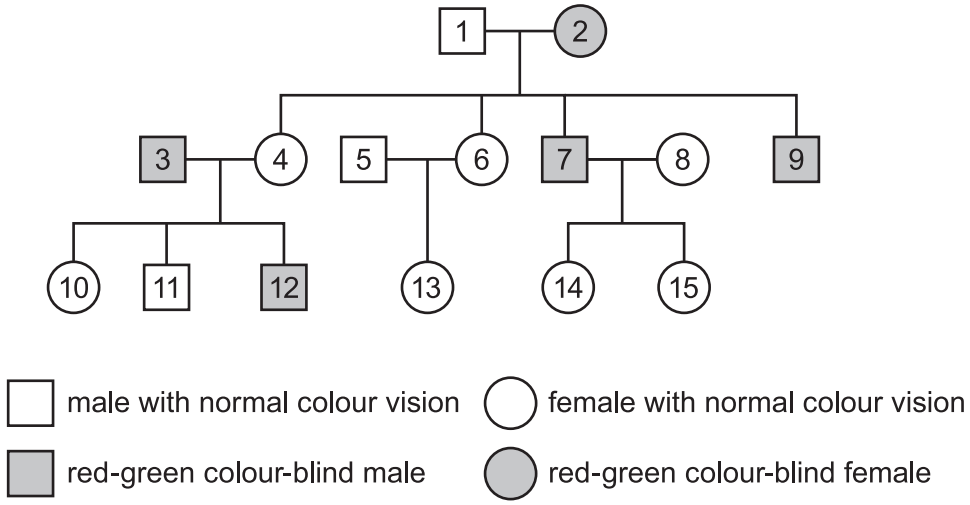


Fig. 5.1

(a) Explain why all of the male children of parent **1** and parent **2** are red-green colour-blind.

.....

.....

.....

.....

..... [2]

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(b) Parent **4** is a female who has normal colour vision and is heterozygous for red-green colour blindness.

Complete the genetic diagram to determine the probability that the offspring of parent **3** and parent **4** would be red-green colour-blind.

parents	**3**	x	**4**
parental phenotypes	red-green colour-blind male	x	female with normal colour vision
parental genotypes	.....	x	.....
gametes	..... , ...	x	..... , ...

offspring genotypes				
offspring phenotypes				

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probability of offspring having red-green colour blindness .....

[5]

[Total: 7]

Monohybrid inheritance Click for more variations

8(a)	*any two from:* parent 2, is homozygous recessive / has two alleles (for red-green colour blindness) **;** only parent 2 can provide the X chromosome for male children **;** males only have one X chromosome and they only need one recessive allele (to be red-green colour blind) **;** red-green colour blindness is a sex-linked characteristic **;**	**2**	

8(b)	*parental genotypes:* parent 3 X^bY **and** parent 4 X^BX^b **;** *gametes:* X^b , **Y/0/-** **and** X^B, X^b **;** *offspring genotypes* | X^BX^b, | X^BY | X^bX^b | X^bY **;** *offspring phenotypes* | normal (colour vision) female | normal (colour vision) male | colour-blind female | colour-blind male **;** *probability:* 0.5 / 50% **;**	**5**	

9 **(a)** Meiosis and mitosis are important processes in the life cycles of organisms.

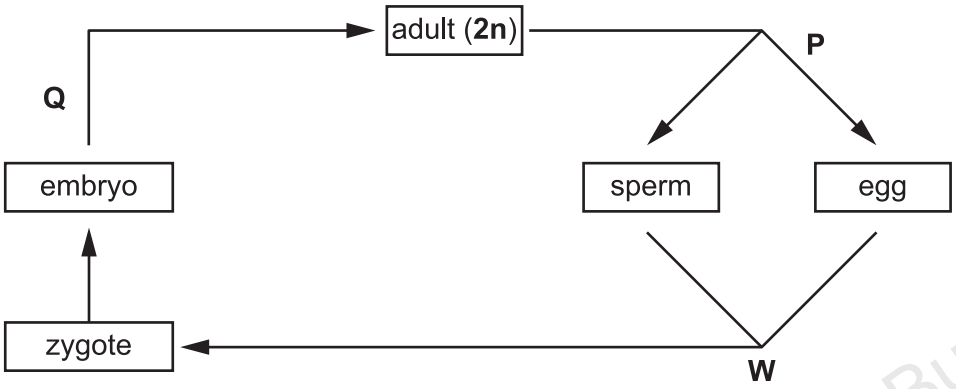
Fig. 3.1 shows the life cycles of two different organisms.

Organism **1** has a simple life cycle.

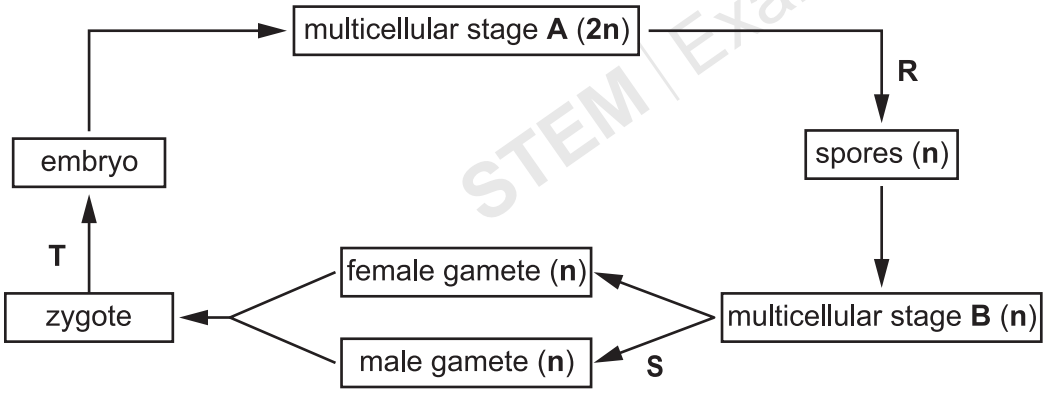
Organism **2** has a complex life cycle. It has a stage **A** that produces spores and a stage **B** that produces gametes.

In the diagrams, the haploid number of chromosomes is represented by **n.** The diploid number of chromosomes is represented by **2n**.

organism **1**



organism **2**



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Fig. 3.1

(i) Table 3.1 shows the letters **P** to **T** in Fig. 3.1 and the type of nuclear division.

Place a tick (✓) in each row to indicate the type of nuclear division that occurs at each of the letters, **P** to **T**.

Table 3.1

letter in Fig. 3.1	meiosis	mitosis
P		
Q		
R		
S		
T		

[3]

(ii) State the name of process **W** shown in Fig. 3.1.

..... [1]

(iii) An embryo contains stem cells.

Complete the sentences about stem cells and body cells.

Stem cells are ..... cells that divide by

..... to produce daughter cells that can become

..... for a specific function.

Most body cells in an organism contain the same genes, but many genes in a particular cell are not ..... because the cell only makes the specific ..... it needs.

[5]

(b) State the events in the life cycle diagram for organism **1** in Fig. 3.1 that would **not** be present in a life cycle diagram for **asexual** reproduction.

.....

.....

.....

.....

..... [2]

[Total: 11]

Mitosis and meiosis Click for more variations

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9(a)(i)	<table><tr><th>letter in Fig. 3.1</th><th>meiosis</th><th>mitosis</th></tr><tr><td>**P**</td><td>✓</td><td></td></tr><tr><td>**Q**</td><td></td><td>✓</td></tr><tr><td>**R**</td><td>✓</td><td></td></tr><tr><td>**S**</td><td></td><td>✓</td></tr><tr><td>**T**</td><td></td><td>✓</td></tr></table> ;;;	**3**	**R** rows with more than one tick 5 rows correct = 3 marks 3 rows or 4 rows correct = 2 marks 2 rows correct = 1 mark 1 row or no rows correct = 0 marks
9(a)(ii)	fertilisation ;	**1**	
9(a)(iii)	1 unspecialised / undifferentiated ; 2 mitosis ; 3 specialised / differentiated ; 4 expressed / AW ; 5 protein(s) / (poly)peptide(s) ;	**5**	
9(b)	*any two from:* 1 meiosis / **P** / haploid stage ; 2 formation of, gametes / egg / sperm ; 3 process **W** / fertilisation / fusion of nuclei (of gametes) OR zygote / embryo, formed ;	**2**	

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10 Fig. 2.1 is a diagram of part of a DNA molecule.



Fig. 2.1

(a) Draw a circle on Fig. 2.1 to identify **one** pair of bases. [1]

(b) The percentage of **T** bases in the DNA of a species is 29%.

Calculate the percentage of bases that would be base **G** in the DNA of this species.

Space for working.

G .....% [1]

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(c) (i) State the name given to a length of DNA that codes for a protein.

..... [1]

(ii) Explain how proteins are made by a cell.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

(iii) DNA controls cell function by controlling the production of proteins.

State **two** types of cell membrane proteins.

1 .....

2 .....

[2]

[Total: 10]

Chromosomes, genes and protein synthesis Click for more variations

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10(a)	circle <u>one</u> pair of the inward pointing horizontal sections opposite each other ;	**1**	
10(b)	21(%) ;	**1**	
10(c)(i)	<u>gene</u> ;	**1**	
10(c)(ii)	*any five from:* ribosomes make, proteins / polypeptides ; mRNA is copied from, gene / DNA ; DNA stays in the nucleus / mRNA is made in nucleus / mRNA leaves nucleus / mRNA moves to cytoplasm ; mRNA passes through ribosome / AW ; ribosome, assembles amino acids / translates mRNA (into a protein) / AW ; (protein synthesis) uses energy ; order of amino acids determined by <u>base sequence</u> of, mRNA / DNA / gene ;	**5**	
10(c)(iii)	*any two from:* carriers ; receptor(s) (proteins) ; maltase / enzyme ; AVP ;	**2**	

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