17. Inheritance

17.4 Monohybrid inheritance

Paper 3 and 4

Question Paper

Paper 3

Questions are applicable for both core and extended candidates

1 **(a)** The melanin gene in humans codes for a pigment produced in the skin, hair and eyes.

(i) Describe what is meant by the term gene.

.....

.....

..... [2]

(ii) State the name of a cell structure in humans that contains genes.

..... [1]

(b) Albinism is a genetic condition where there is a mutation in the gene that produces melanin.

People with albinism have very pale skin, hair and eyes.

In a population, 1 in 18 000 are people with albinism.

Calculate how many people with albinism would be expected in a population of 270 000 people.

..... people [1]

(c) The allele for normal melanin production is dominant and is represented by the letter **A**.

The allele for albinism is recessive and is represented by the letter **a**.

Fig. 5.1 is a pedigree diagram showing the inheritance of albinism in one family.

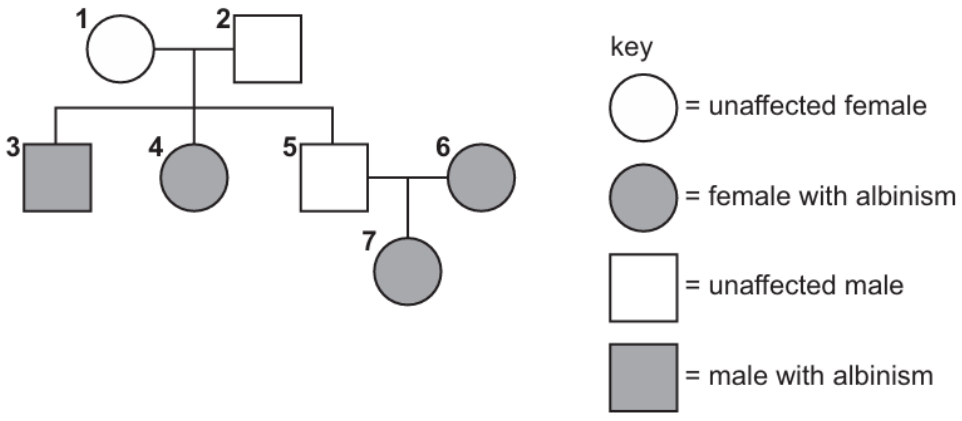


Fig. 5.1

(i) State the sex chromosomes for person **1** in Fig. 5.1.

..... [1]

(ii) State how many people in Fig. 5.1 have albinism.

..... [1]

(iii) Circle the correct description of the genotype of person **3** in Fig. 5.1.

heterozygous **homozygous dominant** **homozygous recessive**

[1]

(d) An unaffected person has a child with a person with albinism.

Complete the genetic diagram to show the possible genotypes and phenotypes of this child.

parental phenotype unaffected person X person with albinism

parental genotypes Aa X aa

parental gametes 

offspring genotypes				
offspring phenotypes				

ratio of unaffected people : people with albinism .....

[4]

[Total: 11]

2 **(a)** Inheritance is the transmission of genetic information from generation to generation.

The boxes on the left show some of the terms used when describing inheritance.

The boxes on the right show definitions for these terms.

Draw **four** straight lines to link each term with its definition.

term	**definition**
	an allele that is expressed if it is present
dominant	
	genetic make-up of an organism
genotype	
	having two different alleles of a particular gene
heterozygous	
	having two identical alleles of a particular gene
phenotype	
	observable features of an organism

[4]

3 **(b)** Fig. 3.1 shows a photograph of a guinea pig with a rough coat and a guinea pig with a smooth coat.

rough coat smooth coat

Fig. 3.1

The allele for a rough coat is dominant and represented by the letter **R**.
The allele for a smooth coat is recessive and represented by the letter **r**.

Fig. 3.2 is a pedigree diagram showing the inheritance of coat texture in some guinea pigs.

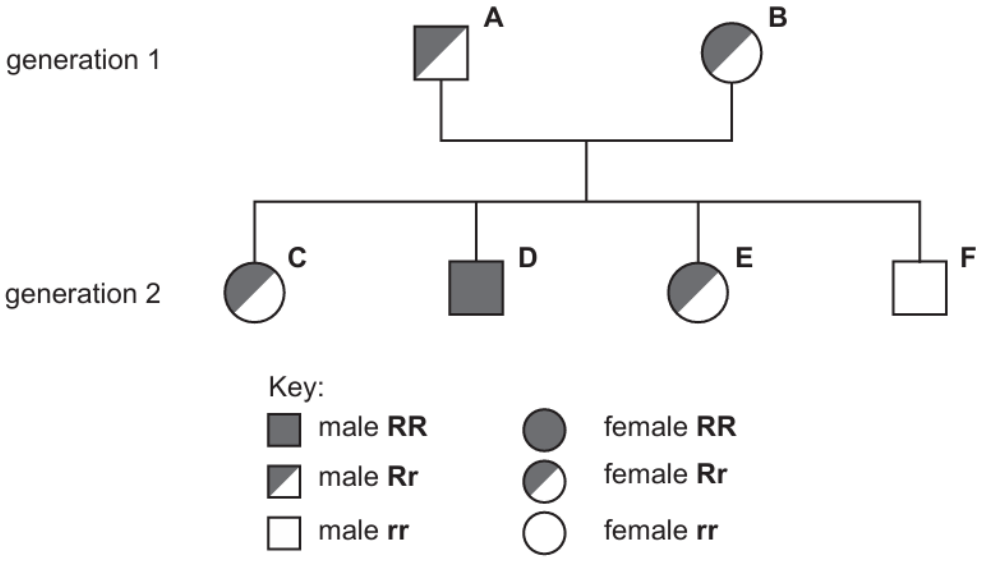


Fig. 3.2

(i) State the total number of guinea pigs with smooth coats in Fig. 3.2.

..... [1]

(ii) State the letter of a guinea pig that has a homozygous dominant genotype in Fig. 3.2.

..... [1]

(iii) State the total number of male guinea pigs in Fig. 3.2.

..... [1]

(c) Two guinea pigs are bred together.

- The genotype of the male guinea pig is **RR**.
- The genotype of the female guinea pig is **Rr**.

Complete Fig. 3.3 to show the:

- possible genotypes of the offspring from this cross
- the probability of offspring having a smooth coat.

		male	
		.....	.....
female	.....	.....	.....
	.....	.....	.....

probability of offspring having a smooth coat .....

Fig. 3.3

[3]

(d) Complete the sentence about breeding.

Two identical homozygous individuals that breed together will be

..... -breeding. [1]

[Total: 9]

4 **(a)** A species of pea plant can produce green or yellow peas.

Fig. 3.1 shows a photograph of a green pea and a yellow pea.

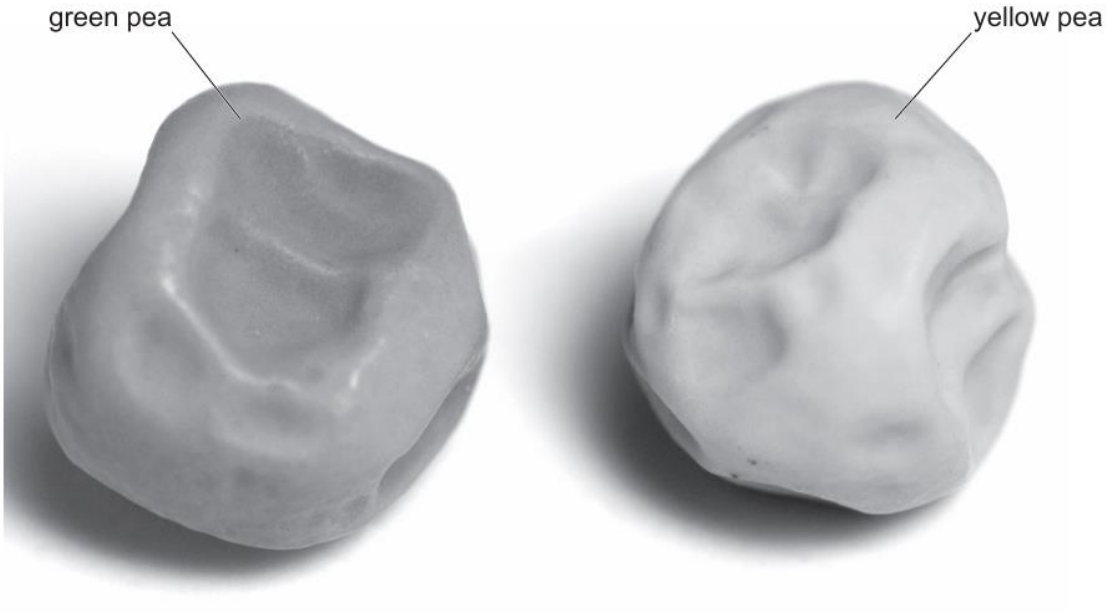


Fig. 3.1

The colour of peas is controlled by a single gene:

- The allele for yellow peas is dominant and is represented by the letter **G**.
- The allele for green peas is recessive and is represented by the letter **g**.

(i) Use your knowledge and this information to complete Table 3.1.

Table 3.1

genotype of pea **A**	
phenotype of pea **B**	
phenotype of a pea with a heterozygous genotype	

[3]

(ii) Two pea plants were crossed.

Complete the genetic diagram in Fig. 3.2 to show the outcome of the cross.

		parental gametes	
		g	**g**
parental gametes	**G**	.....	.....
	g	.....	.....

ratio of yellow offspring : green offspring ..... : .....

[2]

Fig. 3.2

(b) Cystic fibrosis is a disease caused by a recessive allele in humans.

Fig. 3.3 is a pedigree diagram showing the inheritance of cystic fibrosis in a family.

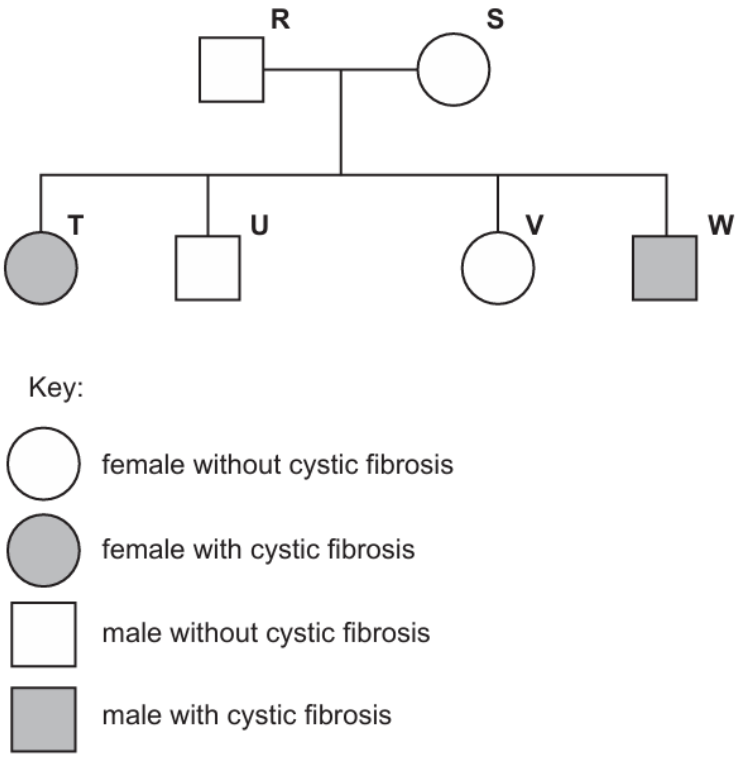


Fig. 3.3

(i) State the number of people that have cystic fibrosis.

..... [1]

(ii) Identify the letter of a person that **must** have a heterozygous genotype.

..... [1]

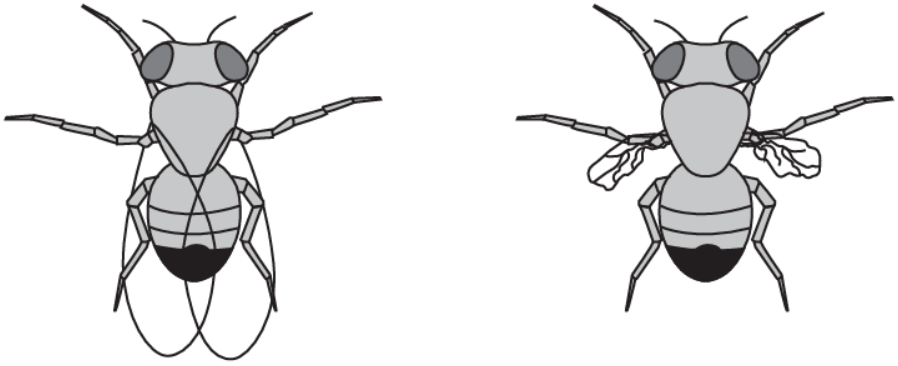
(iii) Person **U** has a homozygous dominant genotype.

Circle the probability of person **U** having a child with cystic fibrosis.

0% **25%** **50%** **75%** **100%** [1]

[Total: 8]

5 **(b)** Fig. 4.1 is a diagram of a fruit fly with normal wings and a fruit fly with vestigial wings.



normal wings **vestigial wings**

Fig. 4.1

A gene determines whether fruit flies have normal wings or vestigial wings.

There are two alleles for this gene:

- **A** is dominant and represents the allele for normal wings
- **a** is recessive and represents the allele for vestigial wings.

(i) A homozygous dominant fruit fly was crossed with a heterozygous fruit fly.

Complete the genetic diagram to predict the probability of the offspring having vestigial wings.

parental phenotypes normal wings × normal wings

parental genotypes ..... × .....

gametes ..... , ... × ..... , ...

offspring genotypes ....

offspring phenotypes ....

probability of offspring having vestigial wings .....

[5]

(ii) State the genotype of a pure-breeding fruit fly that has normal wings.

..... [1]

(iii) The binomial name for a fruit fly is *Drosophila melanogaster*.

State the genus of this fruit fly.

..... [1]

6 Fig. 8.1 shows a cat with an inherited condition that means the cat has extra toes.

Fig. 8.1

The allele that causes this condition is dominant to the allele for the normal condition.

Fig. 8.2 shows the inheritance of this condition in a family of cats.

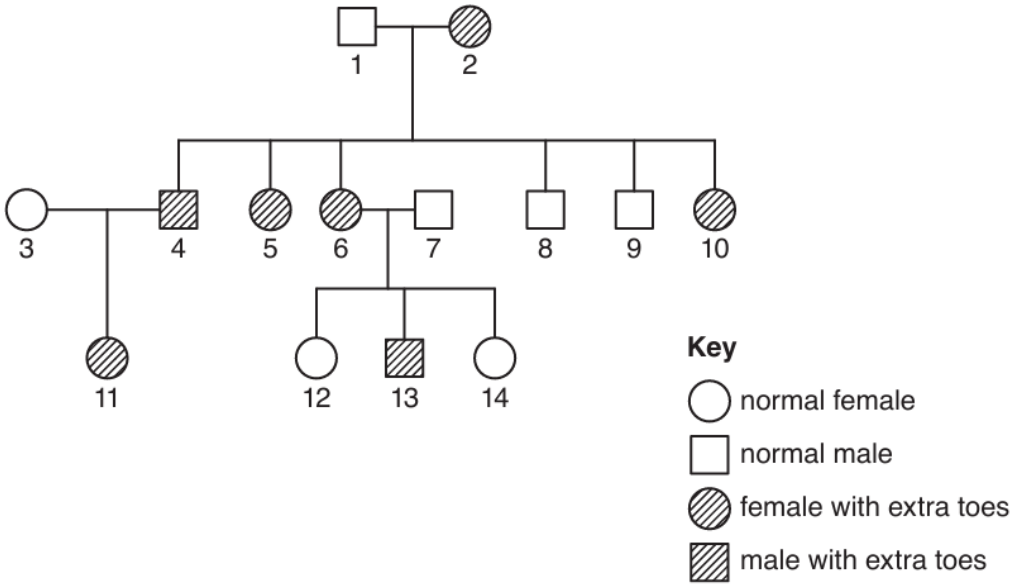


Fig. 8.2

Complete Table 8.1 by stating the genotypes of the numbered individuals.

Use **B** for the dominant allele and **b** for the recessive allele.

Table 8.1

number of individual in Fig. 8.2	genotype of individual
1	
2	
4	
14	

[4]

7 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.

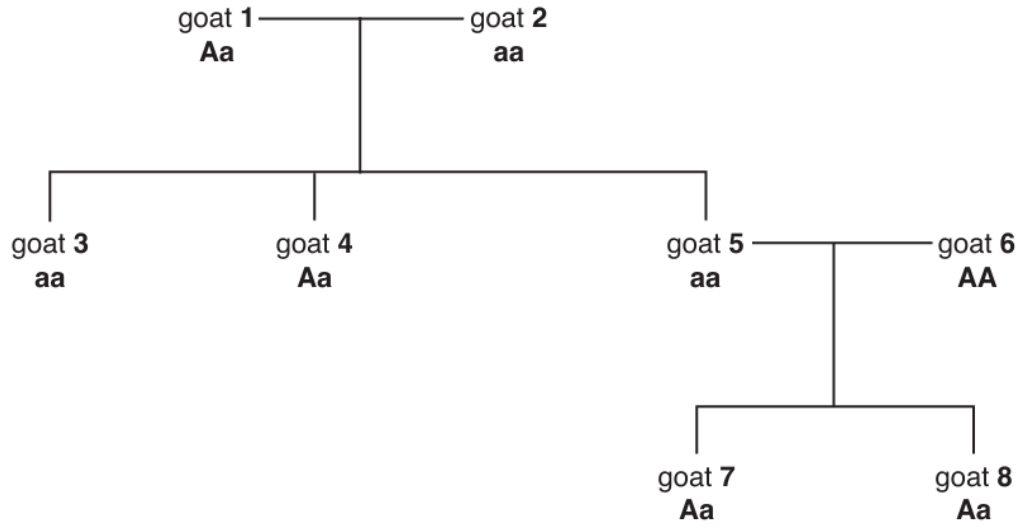


Fig. 7.2

(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			

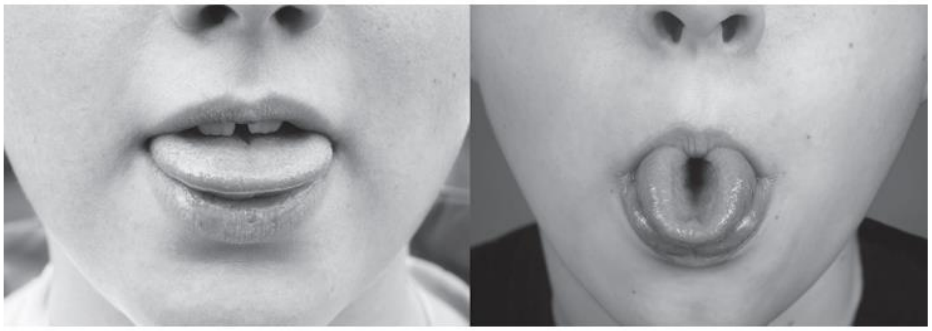
phenotypic ratio ..... white : ..... black

[3]

8 **(b) (i)** Some humans have the ability to roll their tongues and some cannot roll their tongues.

This characteristic is controlled by genes.

Fig. 6.2 shows two boys: boy **A** cannot roll his tongue and boy **B** can roll his tongue.



boy **A** boy **B**

Fig. 6.2

The allele for tongue rolling (**T**) is dominant to the allele for non-tongue rolling (**t**).

Fig. 6.3 shows a family tree for this characteristic. Individual **1** and his partner are both heterozygous for tongue rolling.

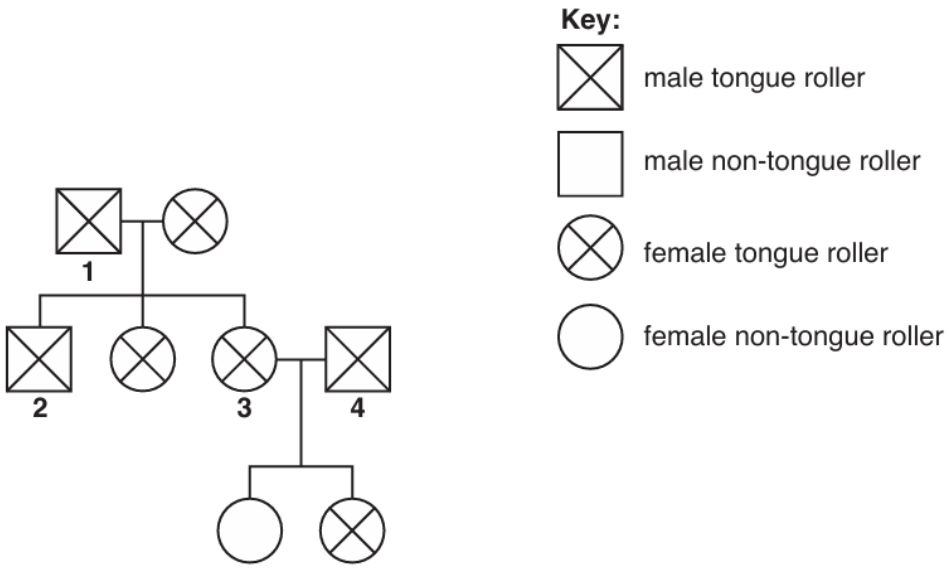


Fig 6.3

Complete Table 6.1 by inserting the genotypes of the numbered individuals in Fig. 6.3.

Table 6.1

individual	genotype
1	
3	
4	

[3]

(ii) Individual **2** in Fig. 6.3 is heterozygous for tongue rolling. He marries a woman who cannot roll her tongue.

State all of the possible genotypes of their children and predict the ratio of phenotypes for their children.

possible offspring genotypes: .....

ratio of phenotypes: .....

[2]

Paper 4

Questions are applicable for both core and extended candidates unless indicated in the question

9 The gene for red-green colour vision is on the **X** chromosome. **(extended only)**

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.

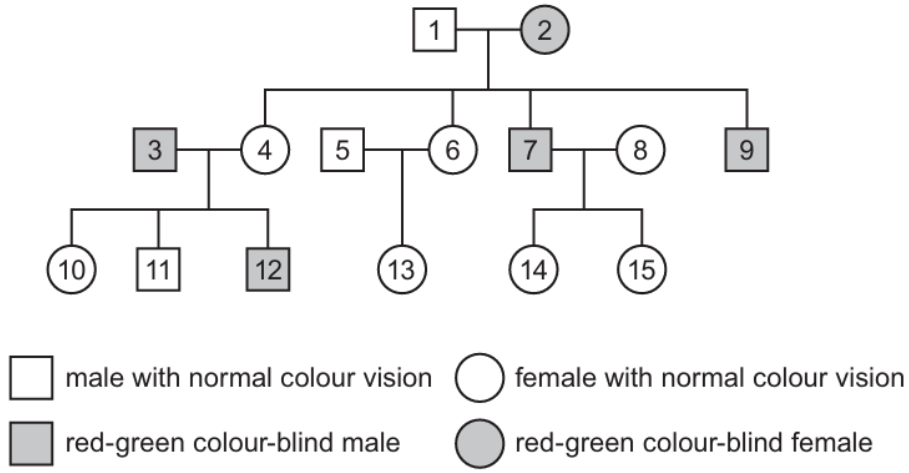


Fig. 5.1

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

.....

.....

.....

.....

..... [2]

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

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				

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

[5]

10 Fig. 5.1 is a pedigree diagram showing the inheritance of blood group in one family. **(extended only)**

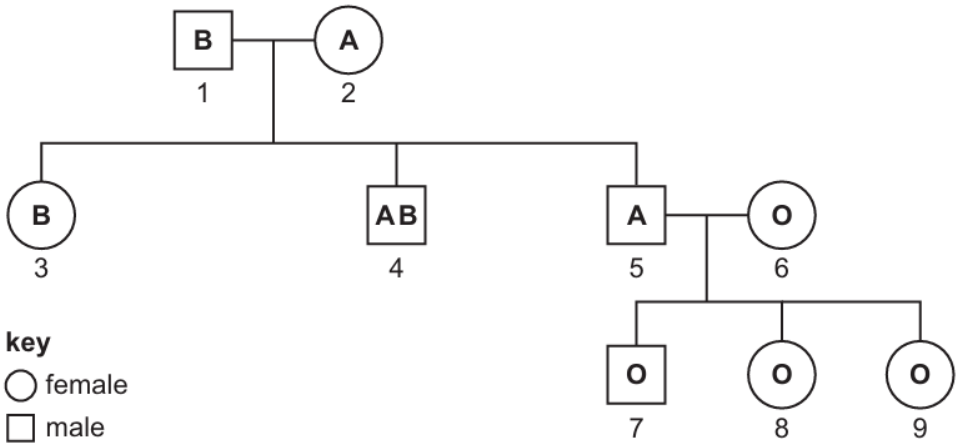


Fig. 5.1

(a) State the number of people in Fig. 5.1 with: **(extended only)**

XY chromosomes .....

only **one** I^A allele. .....

[2]

(d) Explain why the inheritance of blood group is an example of codominance. **(extended only)**

.....

.....

.....

.....

..... [2]

(e) A person with the genotype I^AI^o has a child with a person with the genotype I^BI^o. **(extended only)**

Complete the genetic diagram to determine the probability of the offspring having the blood group **AB**.

	parent 1		parent 2
parental phenotypes	blood group **A**	+	blood group **B**
parental genotypes	I^AI^o	+	I^BI^o
gametes	○ ○	+	○ ○

offspring genotypes				
offspring phenotypes				

probability of the offspring having the blood group **AB** .....

[4]

11 **(e)** If CFTR proteins do not move chloride ions, the liquid in the pancreatic duct becomes very sticky and the duct can become blocked.

Blocked pancreatic ducts are one effect of cystic fibrosis, which is an inherited disease. Cystic fibrosis is caused by a mutation of the gene that codes for the CFTR protein.

Fig. 3.3 shows the pedigree diagram of a family that has two people who have cystic fibrosis.

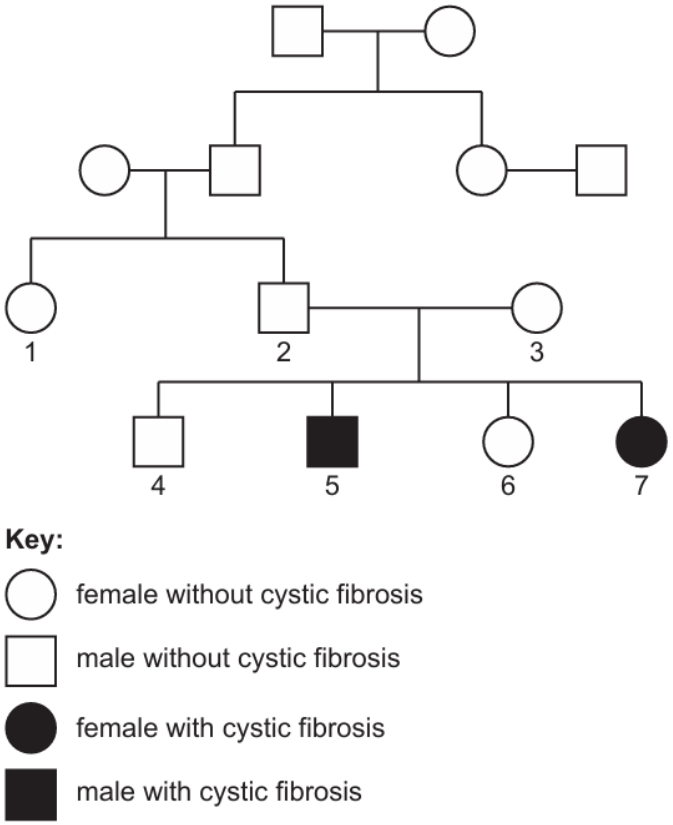


Fig. 3.3

(i) The allele that causes cystic fibrosis is a recessive allele.

Describe **and** explain the evidence shown in Fig. 3.3 that cystic fibrosis is caused by a recessive allele.

.....

.....

.....

.....

..... [2]

(ii) Person 7 is expecting a child with a man who is heterozygous for cystic fibrosis.

Complete the genetic diagram to predict the probability of person 7 and the heterozygous man having a child with cystic fibrosis.

Use the symbol **A** for the dominant allele and **a** for the recessive allele.

parental genotypes ....

gametes  +

genotypes of offspring .....

phenotypes of offspring .....

probability of having a child with cystic fibrosis .....

[5]

12 **(c)** Colour blindness can be caused by a mutation in a gene. The gene is located on the X chromosome. **(extended only)**

Fig. 3.3 is a pedigree diagram of a family which has several people who are colour-blind.

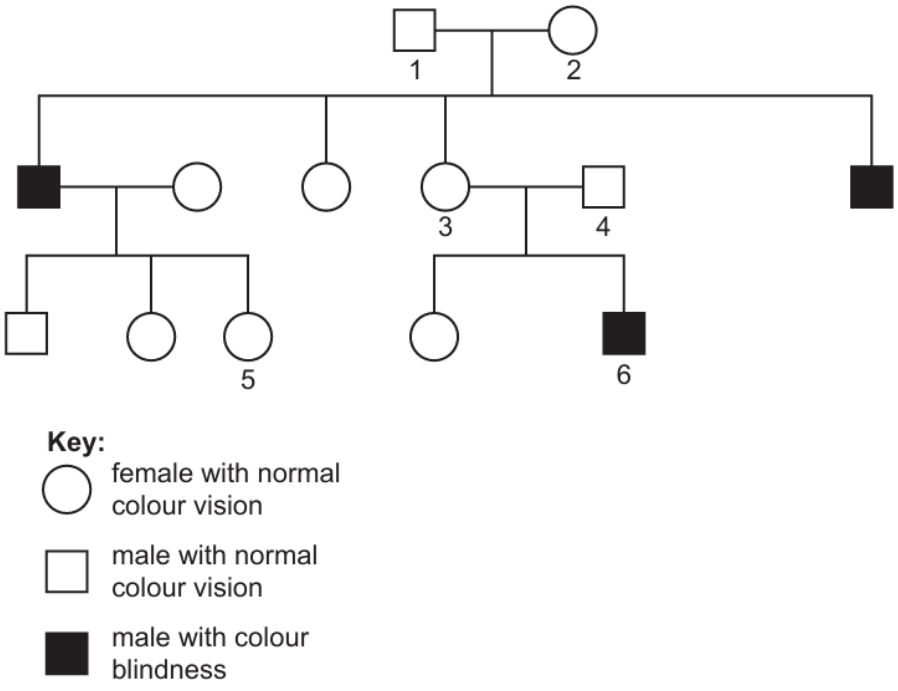


Fig. 3.3

(i) Colour blindness is sex-linked.

State the evidence from Fig. 3.3 that supports the idea that colour blindness is sex-linked. **(extended only)**

.....

.....

..... [1]

(ii) State the genotype of person 5. **(extended only)**

Use the symbols X and Y for the sex chromosomes and **A** for the dominant allele and **a** for the recessive allele of the gene for colour blindness.

..... [2]

(iii) Use the information in Fig. 3.3 to complete the genetic diagram to show the probability of person **3** and person **4** having another child with colour blindness. **(extended only)**

	person **3**		person **4**
parental phenotypes	female with normal colour vision		male with normal colour vision
parental genotypes	.....		.....
gametes	○ ○	+	○ ○

offspring genotypes .....

offspring phenotypes .....

probability of a child having colour blindness .....

[5]

13 **(a)** Two tomato plants that produce red fruit were bred together.

This cross produced 71 offspring plants with red fruit and 26 offspring plants with yellow fruit.

Complete the genetic diagram to show this cross.

Select a suitable letter to represent the alleles and decide which allele will need a capital letter and which allele will need a lower case letter.

letter representing the allele for red fruit .....

letter representing the allele for yellow fruit .....

parental phenotypes	red fruit	×	red fruit
parental genotypes	.....	×	.....
gametes	....., ...	×	....., ...

offspring genotypes .....

expected phenotype ratio ..... red fruit : ..... yellow fruit

actual phenotype ratio 71 red fruit : 26 yellow fruit

[6]

(b) Researchers carried out some experiments on tomato plants that were homozygous for fruit colour.

State how the researchers could be sure that the fruit came from homozygous plants.

.....

.....

..... [1]

14 **(b)** The plant *Camellia japonica* has flowers that can be white, red or a mixture of these two colours. When red-flowered plants are crossed with white-flowered plants, all the offspring plants have flowers with petals that are a mixture of red and white, as shown in Fig. 2.2.

(extended only)

Fig. 2.2

- The gene for petal colour in *C. japonica* is given the symbol **P**.
- The allele for white petals is given the symbol $\mathbf{P^W}$.
- The allele for red petals is given the symbol $\mathbf{P^R}$.

(i) Table 2.1 shows the phenotypes of three different pairs of parent plants.

Complete Table 2.1 by giving all the possible genotypes of the offspring plants that could be produced by these parent plants.

Space for working.

(extended only)

Table 2.1

phenotype of male parent	phenotype of female parent	all the possible genotypes of offspring plants produced by this cross
red petals	red petals	
white petals	red petals	
petals that are both red and white	petals that are both red and white	

[3]

(ii) State the type of inheritance that is shown by petal colour in *C. japonica*. **(extended only)**

..... [1]

15 Colour blindness is a characteristic that is inherited. Colour blindness is more common in males than in females.

Fig. 6.1 is a pedigree diagram showing the inheritance of colour blindness in a family. **(extended only)**

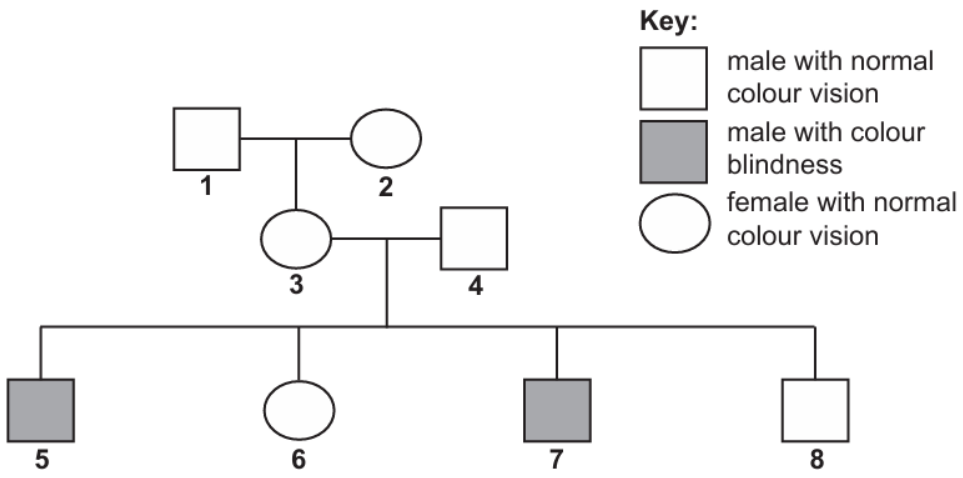


Fig. 6.1

(a) Define the term *inheritance*.

.....

.....

..... [1]

(b) **(i)** Using the symbols **B** and **b**, state the genotypes of individual **5** and individual **8** in the pedigree diagram. **(extended only)**

5 .....

8 .....

[3]

(ii) Individual **3** is a carrier of colour blindness because she has one copy of the allele for colour blindness but has normal colour vision.

Describe the evidence from Fig. 6.1 that shows that individual **3** is a carrier. **(extended only)**

.....

.....

.....

.....

.....

.....

..... [3]

16 **(b)** The king cheetah is a rare variety of *A. jubatus* that has inherited striped fur markings.

Fig. 3.2 shows a cheetah with spots and a king cheetah.

cheetah with spots

king cheetah

Fig. 3.2

(i) Define the term *inheritance*.

.....

.....

..... [1]

Fig. 3.3 shows a pedigree diagram of a population of cheetahs.

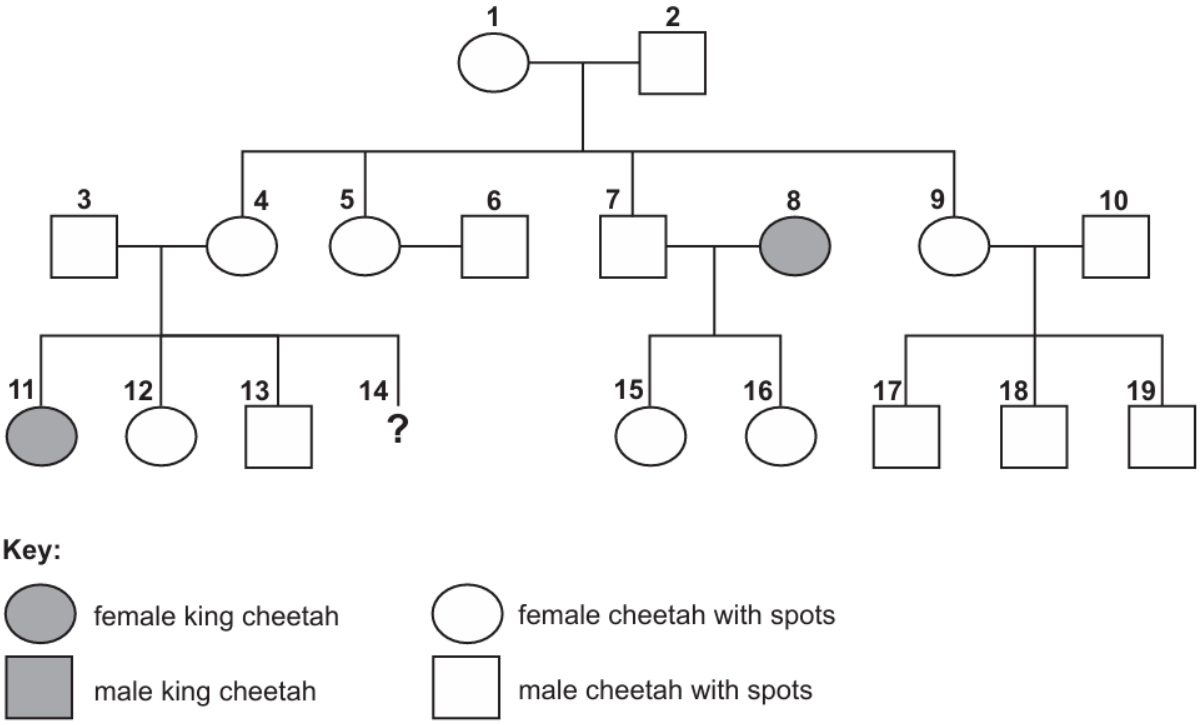


Fig. 3.3

(ii) Deduce the genotype of cheetah **11**.

..... [1]

(iii) Predict the probability of cheetah **14** being a king cheetah.

..... [1]

(iv) Describe how a breeder could determine the genotype of cheetah **17**. **(extended only)**

.....

.....

.....

.....

..... [2]

17 **(d)** Some people inherit colour blindness and cannot identify certain colours, even in bright light.

The gene responsible for colour vision is located on the X chromosome. **(extended only)**

There are two alleles for this gene on the X chromosome:

- X^B – normal colour vision
- X^b – colour blindness.

(i) People that are heterozygous for colour blindness are called carriers.

State the genotype of a heterozygous female carrier. **(extended only)**

.....[1]

(ii) There is no gene for colour vision on the male sex chromosome.

State the genotype of a colour-blind male. **(extended only)**

.....[1]

Fig. 4.2 shows a pedigree diagram for colour blindness.

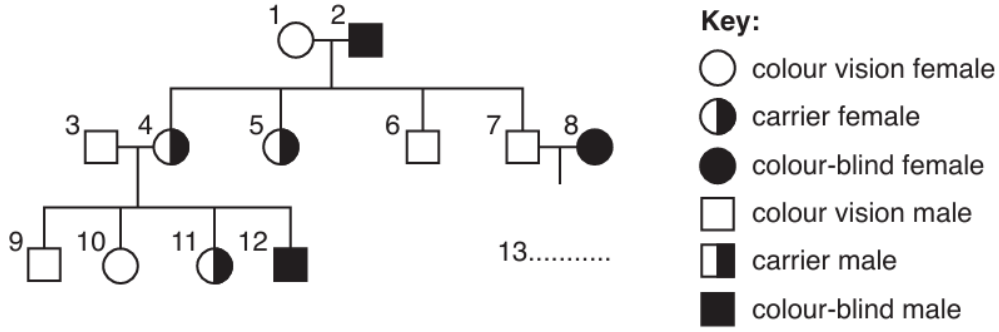


Fig. 4.2

(iii) Person **13** in Fig. 4.2 is male. His parents are person **7** and person **8**. **(extended only)**

Use the key to complete Fig. 4.2 by drawing the correct symbol for person **13**. [1]

(iv) Colour blindness is a sex-linked characteristic. **(extended only)**

Explain why females **4** and **5** are carriers even though their mother is not a carrier.

.....

.....

.....

.....

.....[2]

18 **(c)** Two tall sunflower plants were crossed. 25% of the offspring produced were dwarf.

Explain how it is possible for two tall parent plants to have this percentage of dwarf offspring.

.....

.....

.....

.....

..... [2]

19 **(c)** Haemophilia is a sex-linked blood disorder in which blood takes a long time to clot. Fig. 5.3 is a pedigree diagram showing the inheritance of haemophilia. **(extended only)**

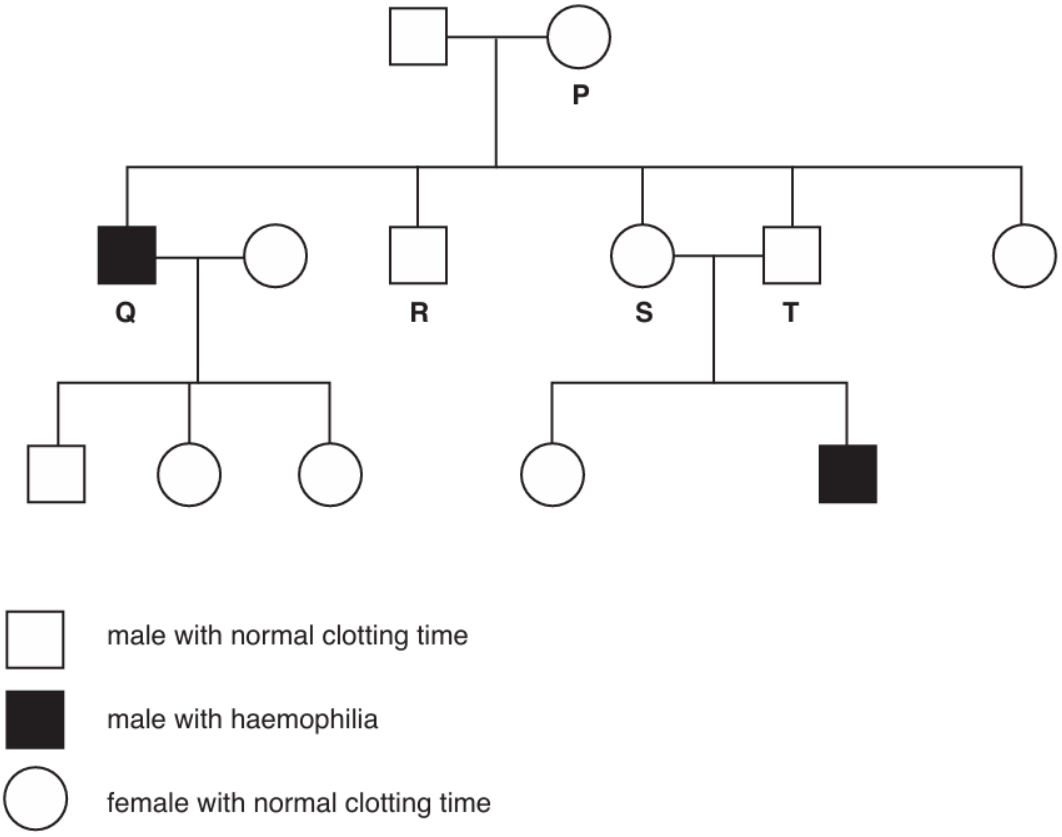


Fig. 5.3

The normal allele is represented by X^H and the mutant allele is represented by X^h.

(i) State the genotypes of the people identified as **P**, **Q** and **R** in Fig. 5.3. **(extended only)**

P .....

Q .....

R .....

[3]

(ii) The couple **S** and **T** are expecting another child.

What is the probability that the child will have haemophilia? **(extended only)**

Space for working

..... [1]

(iii) Define the term *sex-linked characteristic*. **(extended only)**

.....

.....

.....

.....

..... [2]