2 Four different eye pigments in the fruit fly, *Drosophila melanogaster,* are made from the amino acid tryptophan. A simplified metabolic pathway of pigment production is shown in Fig. 2.1.

Three different gene loci control the pathway. Each locus has two alleles. These alleles are **V** or **v**, **C** or **c** and **B** or **b**, as shown in Fig. 2.1.

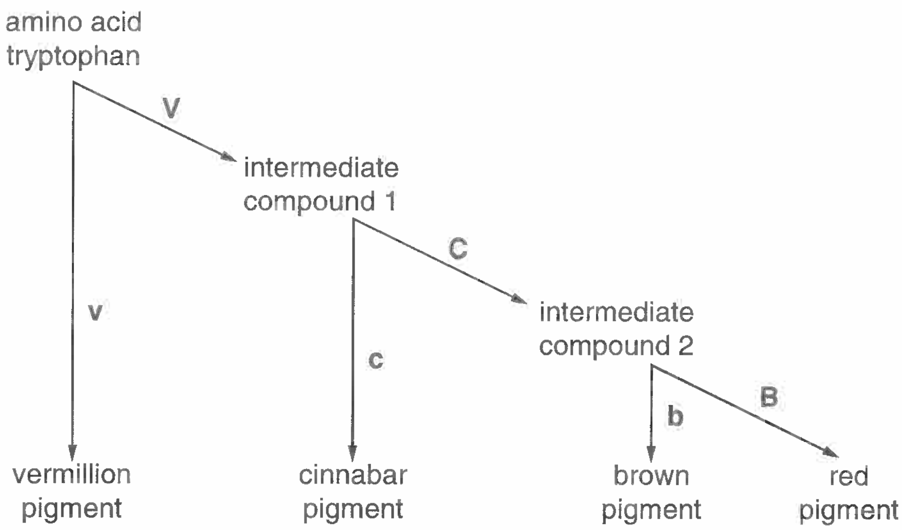

Fig. 2.1

(a) **(i)** Using the information in Fig. 2.1, deduce the phenotypes of flies with the following genotypes:

genotype	*phenotype*
VvCcBb	....
vvCCBB	....
VvccBB	.... **[3]**

(ii) State the term that is applied to this type of gene interaction.

.... **[1]**

(iii) Explain how the products **coded for** by the genes interact to give the different pigments.

....

....

....

....

....

.... **[3]**

(b) A mutation in another gene at another locus in *Drosophila* gives rise to white-eyed flies. The red eye allele of this gene (**R**) is known to be dominant to the white eye allele (**r**).

A student crossed a red-eyed fly with a white-eyed fly, expecting to get an F1 generation of red-eyed flies. In fact, the results were as shown in Table 2.1.

Table 2.1

phenotype of fly	number of offspring
red-eyed female	27
red-eyed male	0
white-eyed female	0
white-eyed male	23

(i) The student first suggested that the reason for there being red-eyed and white-eyed flies in the offspring was that the red-eyed parent was heterozygous.

Explain why this **cannot** be the correct explanation for the results shown in Table 2.1.

....

....

....

.... **[2]**

(ii) In *Drosophila*, the males are the heterogametic sex, possessing two different sex chromosomes, X and Y.

Draw a genetic diagram to show how the results shown in Table 2.1 could have been produced.

Parental genotypes ....

Gametes ....

F_1 genotypes ....

[3]

(iii) The chi-squared (χ^2) test can be used to analyse the results in Table 2.1.

The expected ratio of red-eyed females to white-eyed males is 1:1.

Use Table 2.2 to calculate a value for chi-squared (χ^2).

$$\chi^2 = \Sigma \frac{(O - E)^2}{E} \qquad df = n - 1$$

Key to symbols:

Σ = 'sum of ...'
df = degrees of freedom
n = number of classes
O = observed value
E = expected value

Table 2.2

phenotype of fly	O	E	O – E	$(O - E)^2$	$\frac{(O - E)^2}{E}$
red-eyed female					
white-eyed male					

χ^2 = ...

Use your calculated value of χ^2 and the table of probabilities shown in Table 2.3 to test the significance of the difference between the observed and expected results.

State your conclusion in the space below.

Table 2.3

degrees of freedom	probability, p			
	0.90	0.50	0.10	0.05
1	0.02	0.45	2.71	3.84
2	0.21	1.39	4.61	5.99

Conclusion ....

....

....

.... [4]

[Total: 16]

4 The genetic code carries instructions for the synthesis of polypeptides.

(a) **(i)** State the number of DNA nucleotide bases that code for a single amino acid.

.... [1]

(ii) There is a maximum of 64 different base combinations in DNA that could each code for an amino acid.

How is this number of combinations calculated?

....

.... [1]

(iii) Twenty different amino acids are commonly used for protein synthesis. In theory, this would need only 20 different base combinations.

Explain the uses of the remaining 44 combinations.

....

....

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.... [2]

(iv) Which nucleotide bases are common to DNA and RNA?

....

.... [1]

Question 4(b) begins on page 20

(b) Describe how a nucleotide base sequence in a gene is used to synthesise a polypeptide.

In your answer you should describe the steps of the process in the correct order.

.... [7]

[Total: 12]

3 (a) The fruit fly, *Drosophila melanogaster*, the zebra fish, *Danio rerio*, and the mouse, *Mus musculus*, have all been used by scientists to find out more about how genes control development in all animals, including humans. They are described as 'model organisms'.

(i) Suggest why information gained from studying such model organisms can be applied to humans.

....

....

....

.... **[2]**

(ii) Suggest **two** characteristics that researchers should look for when choosing an organism for research into how genes control development.

1 ....

2 .... **[2]**

(b) Fig. 3.1 and Fig. 3.2, **on the insert**, show the heads of two *Drosophila* fruit flies.

Fig. 3.1 shows a normal wild type fly.
Fig. 3.2 shows a mutant fly.

(i) Name the type of microscope used to take the two pictures.

.... **[2]**

(ii) State one significant difference between the two heads.

....

.... **[1]**

(iii) Name the type of gene which, if mutated, gives rise to dramatic changes in body plan.

.... **[1]**

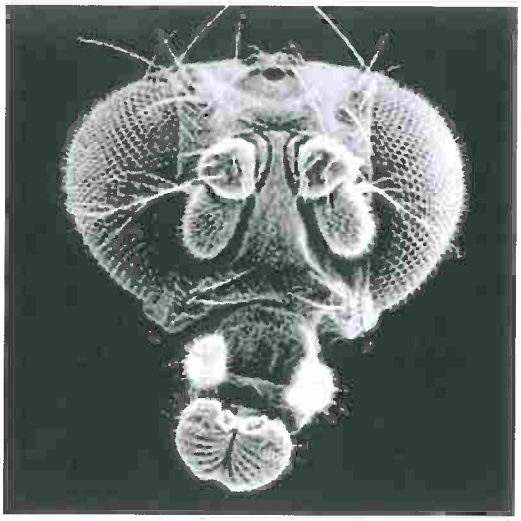

Fig. 3.1

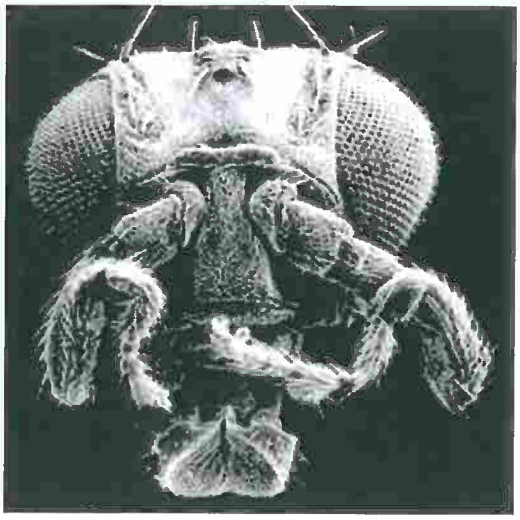

Fig. 3.2

(c) Describe how the information coded on genes is used to synthesise polypeptides **and** how these polypeptides control the physical development of an organism.

In your answer, you should consider both the synthesis of polypeptides and their roles.

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.... [8]

[Total: 16]

Answer **all** the questions.

1 In 1958, scientists made a breakthrough in artificial reproductive cloning by successfully cloning a vertebrate species. The species cloned was the African clawed frog, *Xenopus laevis*.

Fig. 1.1, **on page 2 of the insert**, shows the cloned offspring produced, labelled **D**, as well as the three adult frogs (**A**, **B** and **C**) that were used to create them.

- frog **A**, a brown-coloured female frog, laid eggs, which then had their nuclei removed.
- frog **B**, an albino (white-coloured) female, laid eggs that were fertilised by sperm from **C**.
- frog **C**, an albino male, produced sperm that fertilised the eggs of **B**.

One of the fertilised eggs from **B** was allowed to divide. Nuclei were extracted from the resulting cells and placed into the eggs from frog **A**. These eggs developed into the frogs labelled **D** in Fig. 1.1.

(a) **(i)** The frogs in Fig. 1.1 show discontinuous variation in colour.

Using your knowledge of discontinuous and continuous variation, and the information given, suggest:

one other phenotypic characteristic in which the frogs show a discontinuous pattern of variation

....

one phenotypic characteristic in which they show a continuous pattern of variation.

.... **[2]**

(ii) State the extent to which the environment is likely to affect each of the phenotypic characteristics that you have suggested in **(i)**.

....

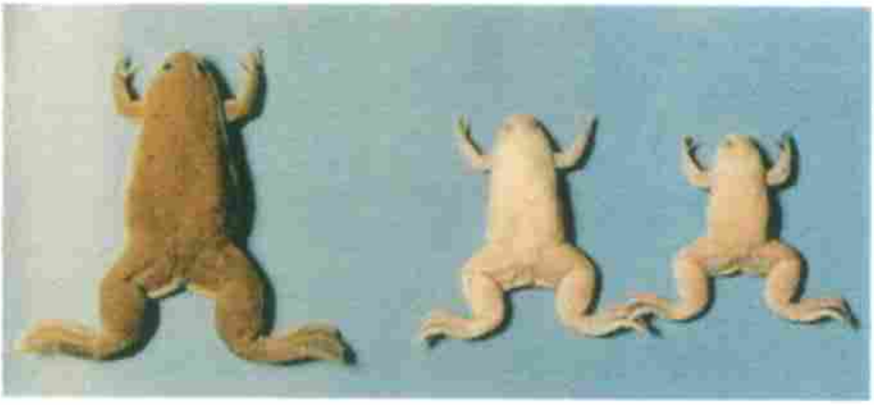
....

....

....

....

.... **[2]**



A B C

D

Fig. 1.1

(iii) Suggest why albino frogs were used to produce the nuclei for transfer.

....

....

....

....

....

.... [2]

Question 1(b) begins on page 4

(b) Samples of DNA were taken from frogs **A**, **B**, **C** and **D**.

Electrophoresis was used to separate the different lengths of DNA after cutting.

Fig. 1.2 shows the results.

These results are known as genetic profiles. Only the genetic profile of frog **C** is identified. The remaining profiles are labelled **1** to **3**.

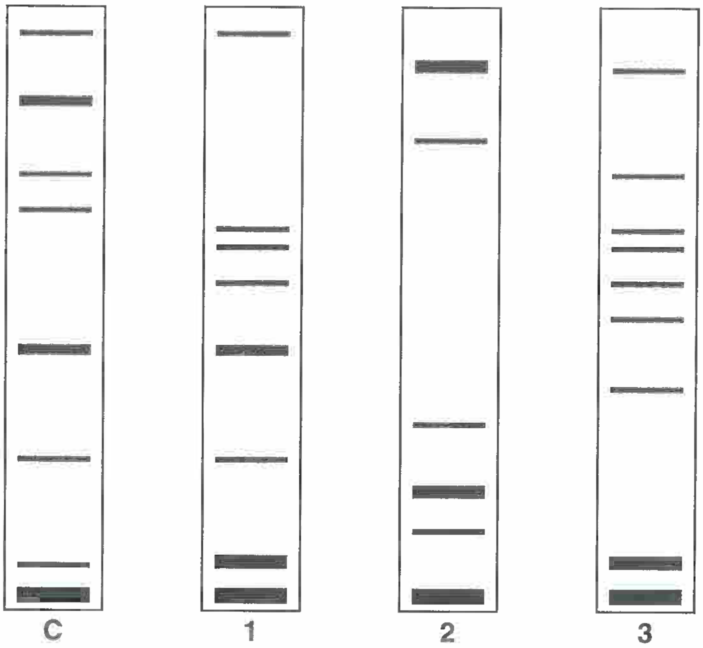


Fig. 1.2

(i) Identify which of the frogs in Fig. 1.1 gave genetic profiles corresponding to **1**, **2** and **3** in Fig. 1.2.

Write the letters **A**, **B** and **D**, as appropriate, in the table below.

Genetic profile number	Letter of frog
1	
2	
3	

[3]

(ii) Mitochondrial DNA from the frogs was sequenced.

State, giving a reason, which of the frogs **A, B** and **C** would have a mitochondrial DNA sequence identical to **D**.

....

.... [1]

(c) In the 1970s, the technique used to clone the frogs was successfully adapted to clone mice from embryos. Cloned mice are used to investigate factors affecting the development and treatment of disease.

(i) State **one advantage** and **one disadvantage** of using clones to test a treatment for a disease.

advantage

....

....

disadvantage

....

.... **[2]**

(ii) In the 1990s, there were further developments in cloning technology when it became possible to make a clone of an adult mammal. The first clone produced from an adult cell nucleus was Dolly the sheep.

Adult cell cloning can be used to investigate the development and treatment of disease.

Outline **two other** potential applications of adult cell cloning.

1 ....

....

....

2 ....

....

....

[2]

Question 1(d) begins on page 6

(d) Identical twins in humans are natural clones. They form when a fertilised egg cell divides by mitosis into two entirely separate groups of cells. Each group of cells develops into a baby.

Two brothers, who were identical twins, married two sisters, who were also identical twins. Each couple had one child.

Fig. 1.3 shows the relationships between these six people.

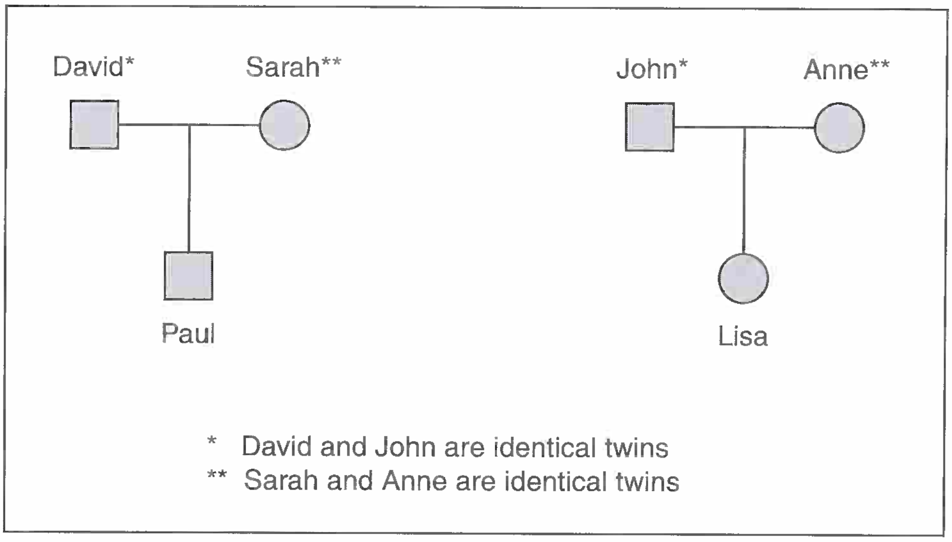


Fig. 1.3

Using your knowledge of mitosis and meiosis, estimate the percentage of alleles shared by the individuals listed in the table below.

Individuals	% of alleles shared
David and John	
Anne and Lisa	
Sarah and Lisa	

[3]

[Total: 17]

6 (a) Fig. 6.1 shows a number of examples of inheritance.

A	An *Antirrhinum* plant with red flowers is crossed with one that has white flowers. All the offspring have pink flowers.
B	A haemophiliac man has children with a woman who is not a haemophiliac. Their daughters all carry the allele for the disease, but their sons do not have the disease.
C	Two *Salvia* plants with purple flowers are crossed. The offspring are produced in the ratio 9 purple-flowered : 3 pink-flowered : 4 white-flowered.
D	A short-haired black mouse crossed with a long-haired brown mouse produces all short-haired black offspring. Mating one of these offspring with the long-haired parent produces mice in the ratio of 1 short-haired black : 1 long-haired black : 1 short-haired brown : 1 long-haired brown.
E	Two snails with plain shells produce 34 offspring with plain shells and 12 with striped shells.

Fig. 6.1

Complete the table below, by matching each of the examples **A** to **E** to the correct explanation of their pattern of inheritance.

Explanation	Letter of example
One gene with two alleles. The alleles show codominance.	
One gene with two alleles located on an autosome (gene not sex linked). One allele is dominant and the other is recessive.	
Two genes for two different characteristics on two different chromosomes.	
A sex linked gene with a dominant and a recessive allele.	
Epistasis, where two genes interact to affect one phenotypic character.	

[5]

(b) The Hardy-Weinberg principle, represented by the equations below, can be used to estimate the frequency of alleles in a population.

$$p^2 + 2pq + q^2 = 1$$

$$p + q = 1$$

Albino rabbits have white fur as these individuals are unable to produce the pigment melanin. The ability to produce melanin is controlled by a gene with a dominant allele (B), resulting in brown fur, and a recessive allele (b), resulting in an albino.

Of the 60 rabbits in a pet shop, 45 are brown.

(i) A student decided to use the Hardy-Weinberg principle to estimate the frequencies of the alleles in this group of rabbits.

Using the Hardy-Weinberg equations, calculate the frequency of the dominant allele in this group.

Show your working.

Frequency of the dominant allele = ... **[3]**

(ii) Give **two** reasons why it was not appropriate to use the Hardy-Weinberg principle to estimate the frequencies of alleles in this group of rabbits in the pet shop.

1 ....

....

....

2 ....

....

....

[2]

[Total: 10]

Answer **all** the questions.

1 **(a)** Fig. 1.1 shows changes over time in the mass of nuclear DNA in some of the cells of the testes of a diploid organism.

During this time period, two different types of nuclear division occurred.

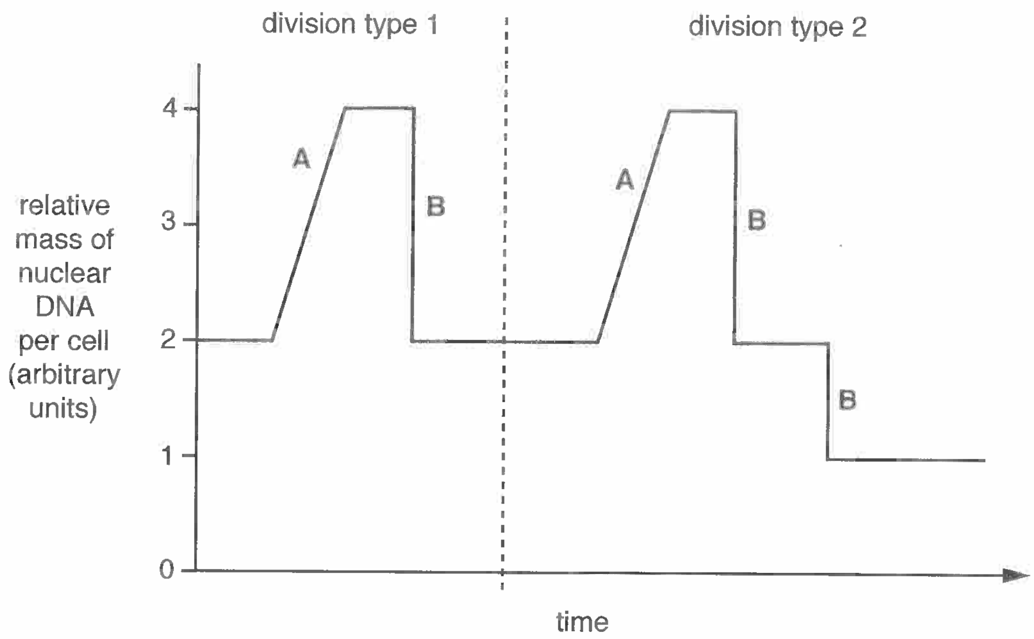


Fig. 1.1

(i) Identify the two types of division represented in Fig. 1.1.

division type 1 ....

division type 2 ....
[1]

(ii) Name the processes that are occurring at the points labelled **A** and **B**, which cause the change in the mass of DNA per cell.

A ....

B ....
[2]

(b) Discuss the ways in which genetic variation is produced, including the role of nuclear division.

In your answer you should link the processes to the ways in which the genetic variation is produced.

[9]

[Total: 12]

3 Gene sequencing is an important technique in molecular biology.

Fig. 3.1, **on page 3 of the Insert**, shows part of a computerised graph obtained from an automated gene sequencing machine.

- The section of the DNA molecule represented in Fig. 3.1 is from base position 117 (on the left of the graph) to base position 137 (on the right of the graph).
- The bases in the DNA sequence are labelled with four different coloured fluorescent dyes.
- The identities of some of the bases (117 to 119 inclusive and 129 to 137 inclusive) are indicated below the graph.

(a) Use Fig. 3.1 to identify the order of bases from positions 120 to 128.

....	....	....	....	....	....	....	....	....
120	121	122	123	124	125	126	127	128

[1]

(b) To produce the type of graph shown in Fig. 3.1, the automated gene sequencing machine needs to be loaded with the following:

- the DNA to be sequenced
- short primer sequences specific to the DNA to be sequenced
- many normal DNA nucleotides
- some chain-terminating DNA nucleotides labelled with coloured dyes
- the enzyme *Taq* polymerase.

A regular cycle of temperature changes allows many DNA fragments of different lengths to be built up by the polymerase chain reaction (PCR).

Fig. 3.2 (**on the next page**) shows the end parts of the sequences of seven of these different length fragments, labelled 1 to 7. The end parts of the sequences for fragments 1 to 4 are complete but those for fragments 5 to 7 are not.
These seven fragments correspond to the **last seven peaks** on the right hand side of the graph in Fig. 3.1.

The letters in boxes represent labelled chain-terminating DNA nucleotides.
The letters not in boxes represent normal DNA nucleotides.

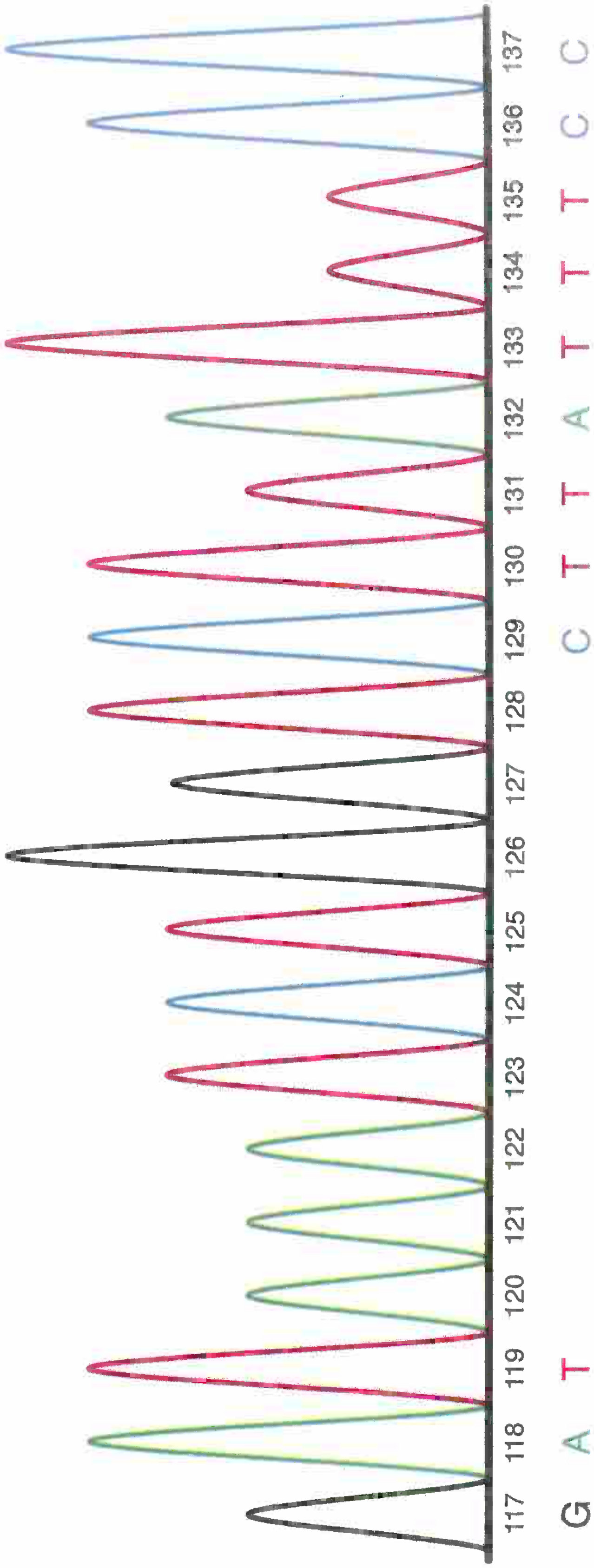

117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137
G A T
C T T T A T T T C C

Fig. 3.1

(i) Use the information in Fig. 3.1 to fill in the missing nucleotide bases on fragments 5 to 7 on Fig. 3.2.

You should distinguish between the normal and labelled nucleotides in the sequence for each fragment.

1 – T

2 – T A

3 – T A T

4 – T A T T

5 – T A

6 – T A

7 – T A

[2]

Fig. 3.2

(ii) Explain how the automated sequencing machine orders the DNA fragments from the PCR reaction into the size order shown in Fig. 3.2.

....

....

....

....

....

....

....

....

.... **[3]**

(c) Gene sequencing can help us to understand how an individual's genome affects their body's response to drugs.

One research study has looked at the effectiveness of drugs used to treat asthma in children. Asthma is a condition in which the bronchioles become reduced in diameter. This results in the child finding it difficult to breathe.

(i) Using your knowledge of the structure of bronchioles, suggest how their diameter might become reduced.

....

....

....

.... **[2]**

(ii) Explain why it is difficult to expel air from the lungs if the bronchioles become reduced in diameter.

....

....

.... **[1]**

(d) Asthma in children may be treated with drugs. One of the most commonly used drugs is salmeterol.

Salmeterol acts by binding to protein receptors in the lining of the bronchioles. However, in approximately 14% of children with asthma, salmeterol is not very effective. This is thought to be the result of a genetic mutation in these children.

Suggest why this mutation reduces the effectiveness of salmeterol.

....

....

....

....

....

....

....

....

.... **[3]**

(e) In a recent medical trial, 62 children with this genetic mutation were studied.

- Their asthma was not controlled well by salmeterol.
- 31 children continued using salmeterol and the remaining 31 were given an alternative drug, montelukast.
- Montelukast is not routinely prescribed because salmeterol is far more effective for most children with asthma.

(i) After one year, the children taking montelukast had better control of their asthma and were able to reduce their use of montelukast.

Suggest why these children responded better to montelukast than to salmeterol.

....

....

....

....

....

.... **[2]**

(ii) Comment on the reliability of the results of this medical trial.

....

....

.... **[1]**

(iii) It is proposed that a simple saliva test could identify those children who have the mutation.

What would be the source of the genetic material used in this test?

....

.... **[1]**

[Total: 16]

4 This question looks at two ways of using mathematical concepts in Biology.

(a) When a new road system was constructed, it split a population of a rare snail species into three smaller populations, **A**, **B** and **C**. As a result, each of these populations became reproductively isolated.

The Hardy-Weinberg principle was used to calculate the relative frequencies, p and q, of a dominant and a recessive allele in each population.

Table 4.1 shows the values of p and q, and the estimated sizes of these three populations.

Snail population	**Estimated population size**	**Immediately after road building**		**10 years after road building**	
		p (frequency of dominant allele)	**q (frequency of recessive allele)**	**p (frequency of dominant allele)**	**q (frequency of recessive allele)**
A	1000	0.50	0.50	0.52	0.48
B	100	0.49	0.51	0.63	0.37
C	10	0.40	0.60	0.20	0.80

Table 4.1

(i) Name the type of isolating mechanism that prevents interbreeding between these three snail populations.

.... [1]

(ii) The habitat of these snail populations did not change over the ten years.

State the term used to describe the **random** changes in allele frequency in a small population.

.... [1]

(iii) Explain which of the populations, **A**, **B** or **C**, experienced most genetic change.

....

....

....

....

....

.... [2]

(b) The inheritance of different alleles in fruit flies, *Drosophila* spp., has been studied extensively in the laboratory.

Two genes that affect the appearance of *Drosophila* are:

R / r red / pink eyes
Y / y yellow / ebony body

Flies known to be heterozygous at both of these loci were crossed with homozygous pink-eyed ebony flies.

Based on the hypothesis that the two genes assort independently, the offspring expected from this cross would be four different phenotypes in a ratio of 1:1:1:1.
The results obtained, however, are shown in Table 4.2.

Phenotype	Expected number	Observed number
Red eye, yellow body	360	6
Pink eye, yellow body	360	701
Red eye, ebony body	360	729
Pink eye, ebony body	360	4

Table 4.2

The chi-squared (χ^2) test can be used to assess whether the results in Table 4.2 are significantly different from the expected results.

The equation for working out the value of χ^2 is given below.

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

where Σ = 'sum of ...'
O = observed value
E = expected value

(i) Calculate the value of χ^2 **to the nearest whole number** for the genetic cross results shown in Table 4.2.

Complete the table below and determine the value of χ^2.

Phenotype of fly	O – E	$(O - E)^2$	$\frac{(O - E)^2}{E}$
Red eye, yellow body	–354	125316	348
Pink eye, yellow body	341	116281	323
Red eye, ebony body			
Pink eye, ebony body			

χ^2 = ... [3]

(ii) Statistical tables show that, for this data set, if χ^2 has a value of 11.35, the observed results would only be produced by chance in 1% of trials.

Use this information and the value for χ^2 that you have calculated in **(i)** to explain whether the original hypothesis should be accepted or rejected.

....

....

.... [1]

(iii) The difference in the observed numbers from the cross compared with the expected numbers has **not** occurred by chance. Suggest a genetic explanation for this difference.

....

....

....

....

....

....

....

.... [3]

[Total: 11]

3 (a) The following boxes show the names of different stages that occur during **meiosis**.

anaphase I | metaphase II | anaphase II

telophase II | prophase I | metaphase I

State the stage(s) in which the following events occur:

independent assortment ....

formation of the spindle apparatus ....

separation of sister chromatids ....

formation of nuclear membranes ....

chromosomes pulled to opposite poles ....

[5]

(b) Meiosis is used in many organisms for the production of gametes.

Explain why meiosis needs to have twice as many stages as mitosis.

....

....

....

....

....

....

[2]

(c) Meiosis is a source of genetic variation. Mutation is another source of variation.

(i) What feature of the DNA molecule is changed as a result of mutation?

.... [1]

(ii) Discuss the possible effects that mutation can have on the structure and function of a protein.

....

....

....

....

....

....

....

.... [3]

[Total: 11]

5 (a) The Oxford Botanic Garden was founded in 1621 to grow plants for the teaching of medicine. Since that time it has seen many changes. When the ideas of Linnaeus were adopted in the 18th century, the plants were dug up and re-planted in family groups according to his new system of taxonomy.

Recently, the plants have once again had to be re-organised:

- DNA sequencing techniques, together with cladistic analysis, have provided a radical new view of plant evolutionary relationships.
- The same techniques have also improved the ability of researchers to pinpoint new cures for diseases, by examining the closest relatives of plants already known to have medicinal properties.

(i) Comment on what the different arrangements of plants in the Oxford Botanic Garden over time tell us about the nature of scientific knowledge.

....

.... [1]

(ii) Suggest **two** purposes of a plant collection in a modern botanic garden.

....

....

....

.... [2]

(b) DNA sequencing techniques have provided new information about plant relationships.

Outline the **roles** of each of the following procedures **in sequencing a genome**:

(i) the polymerase chain reaction (PCR)

....

....

....

....

.... [2]

(ii) electrophoresis

....

....

....

....

.... [2]

(iii) digestion of DNA by restriction enzymes.

....

....

....

....

.... [2]

(c) Suggest why a genome has to be fragmented before sequencing.

....

....

....

....

.... [2]

Question 5(d) begins on page 14

(d) Table 5.1 lists some plants considered for genome sequencing by the 'Floral Genome Project'. The chromosome numbers and genome sizes in mega base pairs (Mbp) are shown.

One Mbp is equal to 1 000 000 base pairs of DNA.

Name	Chromosome Number(s)	Genome Size (Mbp)
Amborella	2n = 26	870
sweet rush	2n = 18	392
monkey flower	2n = 28	430
blueberry	2n = 12, 4n = 24, 6n = 36	1078

Table 5.1

(i) The sequencing method that will be used is only able to sequence fragments of DNA with a maximum length of 750 base pairs.

Calculate the minimum number of DNA fragments that would need to be sequenced to read the genome of *Amborella*.

Show your working.

Answer = ... **[2]**

(ii) Monkey flower and blueberry belong to the same taxonomic group within the plant kingdom. Only one of the pair was chosen for further sequencing work.

Using the data in Table 5.1, suggest reasons why monkey flower was chosen instead of blueberry.

....

....

....

.... [2]

(iii) Use your knowledge of the effects of polyploidy in bread wheat to suggest one way in which the fruit of a hexaploid (6n) blueberry might differ in appearance from that of a diploid (2n) blueberry.

.... [1]

(e) DNA sequence information is most useful when used with the phylogenetic (cladistic) approach to classification.

How does the phylogenetic approach to classifying species differ from the biological species concept?

....

....

....

....

....

.... [2]

[Total: 18]

6 (a) Many species of insects have evolved resistance to chemical insecticides.

Three different patterns of resistance in insect species **R**, **S** and **T** are shown in Fig. 6.1.

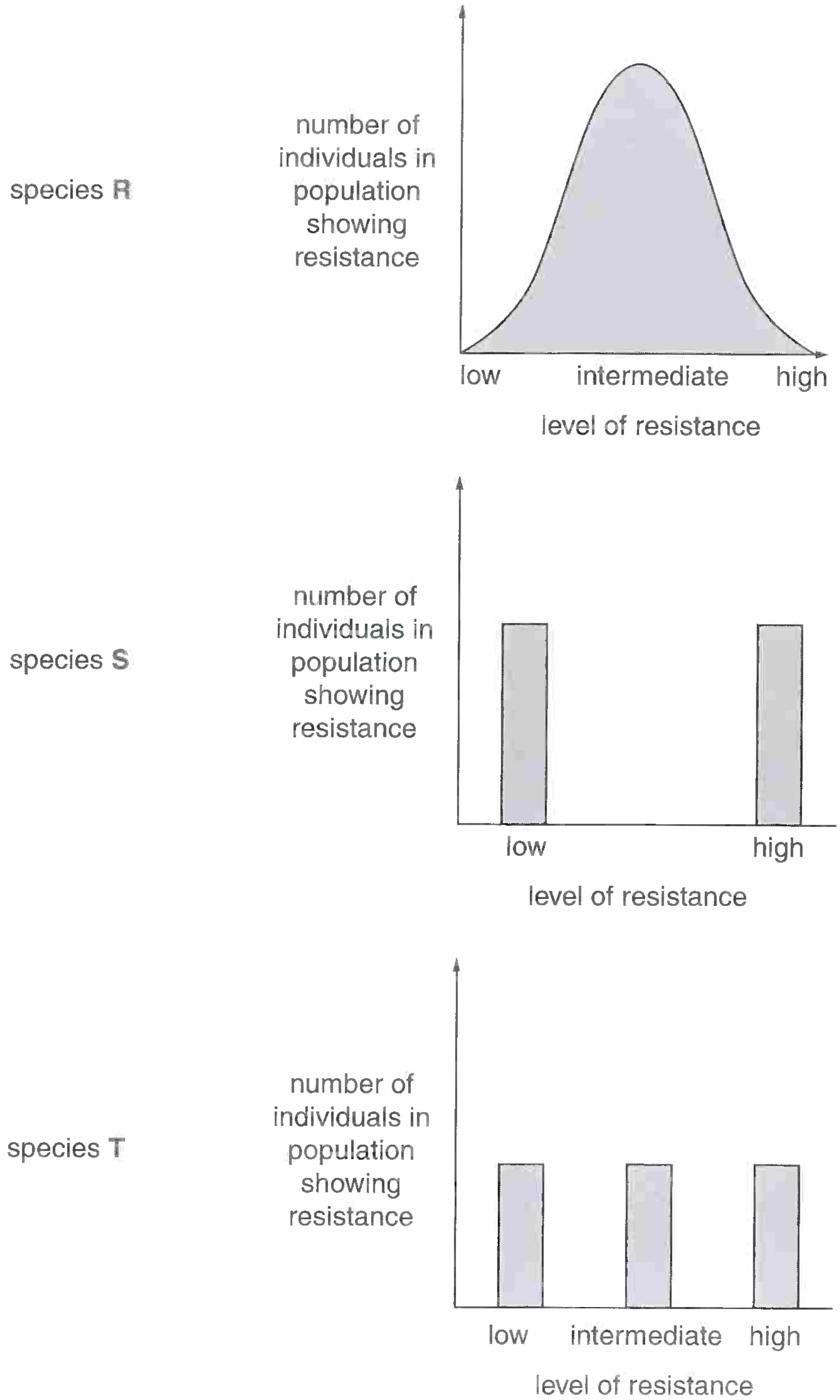


Fig. 6.1

(i) Complete the table below with the letter(s), **R**, **S** and **T**, to indicate which species show a continuous pattern of variation and which species show a discontinuous pattern.

	Discontinuous	**Continuous**
Species identified by letter		

[2]

(ii) A student noted a number of statements on his revision card that referred to the patterns of resistance shown in species **R**, **S** and **T** in Fig. 6.1.

Revision card – patterns of resistance

1. It's controlled by a single gene
2. There is an additive effect
3. May involve multiple alleles
4. Heterozygote shows a distinct phenotype
5. It's controlled by many genes (polygenic)
6. Involves a dominant and a recessive allele
7. Shows co-dominance or incomplete dominance
8. Involves just two alleles

Complete Table 6.1 below, by selecting the correct numbered statement(s) that explain the genetic basis of each pattern of resistance for each species.

You may select a number more than once.

Species	**Statement number(s)**
R	
S	
T	

Table 6.1

[6]

(b) Dog fleas are small parasitic insects that live in the fur of dogs and feed on their blood. Dogs are routinely treated with sprays or powders to kill fleas.

A vet believes that dog fleas may have become resistant to a popular flea-killer product.

He asks an A-level work experience student to plan an experiment to test this hypothesis.

The student needs to sample fleas from dogs visiting the surgery and also fleas from long grass in fields visited by dog-walkers. The fleas then need to be tested for resistance to the flea-killer.

Describe the methods the student could use to:

- collect both samples of fleas
- find out the proportion of fleas that are resistant
- process the data.

In your answer you should describe the methods for collection, testing and data processing in a logical series of steps.

[7]

[Total: 15]

7 (a) Animals and plants need to respond to changes in their environment.

(i) Give **two** reasons why **both** plants and animals need to be able to respond to changes in their environment.

....

....

....

.... [2]

(ii) Plants co-ordinate their responses to environmental stimuli using hormones. Mammals also co-ordinate responses to some stimuli using hormones.

State **three differences** in the ways in which plant and mammalian hormones operate.

....

....

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....

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....

....

.... [3]

(b) Most mammalian hormones are made of protein. An example is human growth hormone (HGH). Lack of this hormone causes dwarfism (short height).

(i) Explain why dwarfism can be described as a genetic condition.

....

....

....

.... [2]

Question 7(b)(ii) begins on page 20

(ii) Children with dwarfism can be given HGH produced by genetic engineering. A method for engineering bacteria to make HGH has many stages that are similar to the method used to produce human insulin, and is described below.

Complete the following paragraph using the most suitable term or terms to fill in the gaps.

The .... for HGH is cut from human DNA using a restriction enzyme. The human DNA fragments are then inserted into plasmids using the enzyme called .... Bacterial cells are treated so that they take up these plasmids. Bacteria that contain the new DNA are described as .... bacteria. They are first grown on agar plates containing .... which allow scientists to distinguish them from bacteria that have not taken up any new DNA. A .... can then be used to identify the bacteria that have the desired sequence of DNA. **[5]**

(c) Steroid hormones are not made of protein. They are classed as lipids. Their structure means that they can diffuse through the cell surface and nuclear membranes. The hormones then bind to DNA in the nucleus and switch genes on and off.

Explain why steroid hormones can diffuse through cell membranes.

....

....

....

.... **[2]**

(d) Steroid hormones are one example of molecules that can switch genes on and off in mammalian cells.

Other molecules involved in genetic control have been studied in both eukaryotes and prokaryotes.

Describe **one** other example of genes being switched on or being switched off by a molecule that binds directly to DNA.

....

....

....

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....

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....

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.... **[4]**

[Total: 18]

END OF QUESTION PAPER

Answer **all** the questions.

1 Domestic chickens have been bred for many years to increase the number of eggs laid by the females. It is useful to be able to identify the young female chicks on the day after they hatch, as only the females need to be kept for laying eggs.

Unlike mammals, where the sex chromosomes are known as X and Y, in chickens the sex chromosomes are known as Z and W.

- Male chickens have two Z chromosomes (ZZ).
- Female chickens have one Z chromosome and one W chromosome (ZW).

(a) Some genes for feather colour and pattern in chickens are carried on the Z chromosome but not on the W chromosome. One such example is the gene for striped feathers (barring).

State the name given to this type of inheritance.

.... **[1]**

(b) Inheritance of the barring pattern can be used to identify female chicks when they are one day old.

The phenotypes associated with the two alleles of the barring gene are shown in Table 1.1.

Allele	**Adult phenotype**	**Day-old chick phenotype**
dominant **B**	black feathers striped with white bars (barred)	black body with a white spot on head
recessive **b**	black feathers (non-barred)	black body and head

Table 1.1

(i) State the **adult phenotypes and sex** of the following individuals:

Z^BZ^b ....

Z^BW ....

Z^bW ....

[3]

(ii) A cross was carried out between a barred female and a non-barred male.

Complete the genetic diagram to show the parental genotypes, their gametes and the F1 genotypes. State the phenotypes of the offspring as **day-old chicks**.

Parent phenotypes	**Barred female**	**Non-barred male**
Parent genotypes	....	....
Gametes	....	....
F1 genotypes	....	....

F1 day-old chick phenotypes

male ....

....

female ....

....

[5]

(c) The autosomal gene **I / i** shows epistasis over **all** other genes affecting feather colour in chickens.

Individuals carrying the dominant allele **I** have white feathers.

Chickens that are not white have the genotype **ii**.

(i) State the precise term used to describe the genotype **ii**.

.... **[1]**

(ii) Predict the colour(s) of the offspring of a cross between a male homozygous barred chicken and a white female chicken with the genotype **II**.

.... **[1]**

[Total: 11]

7 **(a)** A number of new techniques for manipulating cells and genomes are now available, and it is hoped this manipulation will allow cures for diseases to be developed.

Five goals that scientists would like to achieve are described below and are listed **A** to **E**:

A producing large numbers of genetically identical 'model' transgenic mice that show symptoms of diabetes

B growing a replacement kidney identically tissue-matched to an individual patient

C obtaining replacement hearts from transgenic pigs, partially tissue-matched to humans

D genetically manipulating cells of one adult to cure a genetic disease in that individual

E altering a prokaryotic pathogen for use as a vaccine.

The names of the procedures corresponding to **four** of the five goals **A** to **E** are written below.

Match the correct letters to the names. **No letter should be used more than once.**

xenotransplantation ....

somatic gene therapy ....

non-reproductive cloning ....

animal reproductive cloning ....

[4]

(b) Table 7.1 shows four different combinations of techniques used to achieve goals **A** to **E**.

Write the letters **A, B, C, D or E** in the first column of the table to match each goal to the appropriate combination of techniques needed to achieve it.

Use each letter only once.

	Technique			
Goal	**Vector used to transfer genes**	**Embryonic stem cells manipulated**	**Non-embryonic stem cells manipulated**	**Tissue designed for use in a different species**
	✓	✗	✓	✗
	✓	✓	✗	✗
	✗	✓	✗	✗
	✓	✓	✗	✓
	✓	✗	✗	✗

[5]

Table 7.1

[Total: 9]

Answer **all** the questions.

1 This question is about the evolution, genetics, behaviour and physiology of cats.

Fig. 1.1 **(on the insert)** shows a Scottish wildcat, *Felis sylvestris*.

Modern domestic cats evolved from a wild ancestor of similar appearance to the Scottish wildcat.

Fig. 1.2 **(also on the insert)** shows a breed of domestic cat, *Felis cattus*. This breed is called the Colourpoint Persian cat.

(a) State **two** phenotypic differences between the Scottish wildcat in Fig. 1.1 and the Colourpoint Persian cat in Fig. 1.2.

....

....

....

.... **[2]**

(b) Name the process that:

(i) has given rise to the modern domestic cat from its wild ancestor

.... **[1]**

(ii) has given rise to coat colour variation in cats.

.... **[1]**

(c) In Colourpoint Persian cats, interaction between two genes, **B/b** and **D/d**, causes the colour of the face, ears, paws and tail.

The dominant allele, **B**, gives a dark brown colour, known as 'seal'.
The recessive allele, **b**, gives a light brown colour, known as 'chocolate'.

The dominant allele, **D**, has no effect on coat colour.
However, the presence of two copies of the recessive allele, **d**, changes the colour 'seal' to a colour known as 'blue', and 'chocolate' to a colour known as 'lilac'.

(i) State the name given to this type of genetic interaction.

.... **[1]**

(ii) Suggest the possible **genotypes** of a 'seal' Colourpoint Persian cat.

....

[4]

Fig. 1.1

Scottish wildcat

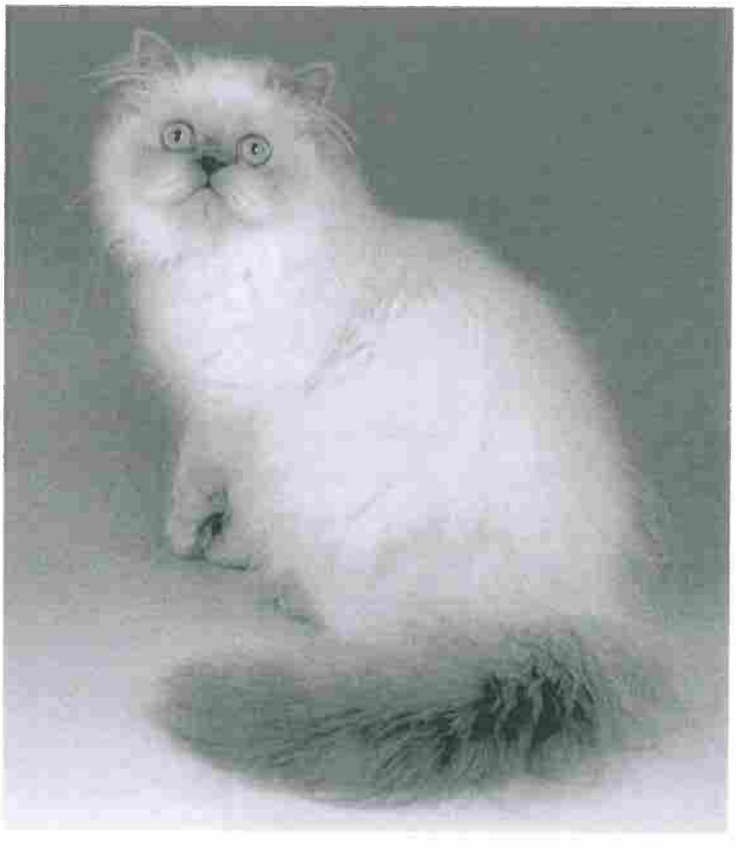

Fig. 1.2

Colourpoint Persian cat

(iii) A 'lilac' Colourpoint Persian cat is homozygous at both the **B/b** and the **D/d** gene locus.

What is meant by the terms **homozygous** and **gene locus**?

homozygous

....

....

....

gene locus

....

....

.... **[2]**

(iv) A cross was carried out between a 'seal' cat and a 'lilac' Colourpoint Persian cat. A Punnett square of the expected genotypes of the offspring of this cross is shown in Table 1.1.

Table 1.1

gametes	**BD**	**Bd**	**bD**	**bd**
bd	BbDd	Bbdd	bbDd	bbdd

Use Table 1.1 to state the **phenotypes** of the offspring and to predict the **phenotypic ratio**.

phenotypes

....

phenotypic ratio

.... **[2]**

(d) Breeders of Colourpoint Persian cats are advised to be present at the birth of the kittens. In this breed, the mother cat may not perform essential maternal behaviour such as licking the newborn kitten to free it from its amniotic sac (the membrane surrounding it at birth).

Wildcat mothers, even when they are first-time mothers, perform this behaviour naturally.

(i) State the type of behaviour shown by these wildcat mothers.

Give **one** characteristic of this type of behaviour.

type of behaviour ....

characteristic ....

.... **[2]**

(ii) Over time, the frequency of domestic cat mothers who perform essential maternal behaviour, such as licking the newborn kitten, has decreased.

Suggest and explain a reason for this change in frequency over time.

....

....

....

....

....

.... **[2]**

(e) Breeding pedigree cats, such as Colourpoint Persian cats, may involve crossing closely related individuals in order to obtain desirable characteristics.

Physiological problems are more common in pedigree animals than in wild animals.

(i) Suggest why physiological problems are more common in pedigree animals.

....

....

....

....

....

.... **[2]**

(ii) An example of a physiological problem in Colourpoint Persian cats is that some of them cannot digest lactose sugar in milk. These cats can be fed lactose-reduced milk which is made by a biotechnological process using immobilised lactase enzyme.

State **two** methods of immobilising an enzyme.

....

....

....

.... **[2]**

[Total: 21]