Q1. Lake Malawi in East Africa contains around 400 different species of cichlids which are small, brightly coloured fish. All these species have evolved from a common ancestor.

(a) Describe **one** way in which scientists could find out whether cichlids from two different populations belong to the same species.

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(2)

(b) During the last 700 000 years there have been long periods when the water level was much lower and Lake Malawi split up into many smaller lakes. Explain how speciation of the cichlids may have occurred following the formation of separate, smaller lakes.

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(4)

(c) Many species of cichlids are similar in size and, apart from their colour, in appearance. Suggest how the variety of colour patterns displayed by these cichlids may help to maintain the fish as separate species.

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(2)
(Total 8 marks)

Q2. A sex-linked gene controls fur colour in cats. Ginger-coloured fur is controlled by the allele **G**, and black-coloured fur is controlled by the allele **g**. Some female cats have ginger and black patches of fur. They are described as tortoiseshell. Male cats cannot be tortoiseshell.

(a) What is meant by a *sex-linked* gene?

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(1)

(b) A male cat with the genotype $\mathbf{X^g\ Y}$ mates with a tortoiseshell female.

(i) Give the phenotype of the male.

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(1)

(ii) Give the genotype of the tortoiseshell female.

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(1)

(iii) Complete the genetic diagram to show the genotypes and the ratio of phenotypes expected in the offspring of this cross.

Parents	Male	Tortoiseshell female
Parental genotypes	$\mathbf{X^g\ Y}$	.....

P*arental gametes*

Offspring genotypes

Offspring phenotypes

Ratio

(3)

(c) The effect of the **G** and **g** alleles is modified by another gene. This gene is not sex-linked and it has two alleles. The allele **d** changes the ginger colour to cream and the black colour to grey. The dominant allele **D** does not modify the effect of **G** or **g**.

A cream-coloured male cat mated with a black female whose genotype was $\mathbf{X^gX^g}$ **Dd**. Male kittens of two different colours were produced. Complete the genetic diagram.

Parental phenotypes	Cream-coloured male	Black female
Parental genotypes	.....	$\mathbf{X^gX^g}$ **Dd**
Parental gametes		
Male kitten genotypes		
Male kitten colours		

(3)
(Total 9 marks)

Q3. The land snail, *Cepaea nemoralis*, is found in a number of different habitats. It is prey to birds such as thrushes. The shells of the snail show variation in colour and in the number of dark bands around them. They may be brown, pink or yellow, and they may have one, three or five bands or none at all.

Shell with no bands

Shell with five bands

Illustrations by Gordon Riley

(a) What type of variation is shown by the banding of the shells? Explain your answer.

Type of variation

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Explanation

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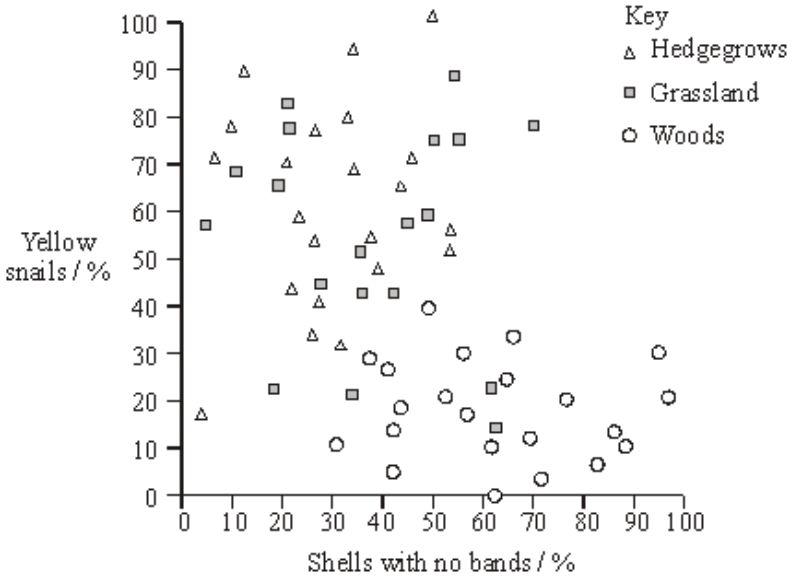
(1)

(b) The graph shows the frequency of yellow, unbanded snails in three habitats. The frequencies were found to be consistent over a period of time.



(i) Describe what the graph shows about the relationship between the habitats and the phenotypes of the snails.

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(2)

(ii) Suggest an explanation for this relationship.

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(4)
(Total 7 marks)

Q4. The production of pigment in rabbit fur is controlled by two genes.

One gene controls whether any pigment is made. This gene has three alleles. Allele **A** codes for the production of one form of the enzyme tyrosinase, which converts tyrosine into a black pigment. Allele $\mathbf{A^h}$ codes for the production of a second form of the enzyme, which becomes inactive at temperatures close to a rabbit's core body temperature, so only the face, ears, legs and tail are pigmented. A third allele, **a**, fails to code for a functional tyrosinase.

The other gene controls the density of pigment in the fur. This gene has two alleles. Allele **B** is dominant and results in the production of large amounts of pigment, making the fur black.

Allele **b** results in less pigment, so the fur appears brown.

(a) How do multiple alleles of a gene arise?

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(2)

(b) The table shows some genotypes and phenotypes.

Genotype	Phenotype
A–B–	all fur black
aaB–	all fur white (albino)
a^habb	white body fur with brown face, ears, legs and tail (Himalayan)

(i) What do the dashes represent in the genotype of the black rabbit?

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(1)

(ii) Give all the possible genotypes for a Himalayan rabbit with black face, ears, legs and tail.

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(2)

(iii) Suggest an explanation for the pigment being present only in the tail, ears, face and legs of a Himalayan rabbit.

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(2)

(c) Using the information given, explain why the phenotypes of rabbits with **AABB** and **Aa^hBB** genotypes are the same.

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(2)
(Total 9 marks)

Q5. In an investigation, the tolerance to copper ions of the grass *Agrostis tenuis* was determined. Samples were taken of plants growing in waste from a copper mine and from nearby areas just outside the mine. The mean copper tolerance of plants from the mine waste was found to be four times higher than that of plants in the surrounding area.

(a) Explain how natural selection could produce a copper-tolerant population in the mine waste.

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(4)

(b) Copper-tolerant *Agrostis tenuis* plants flower at a different time from those which are not copper-tolerant. Explain how this might eventually lead to the production of a new species of *Agrostis*.

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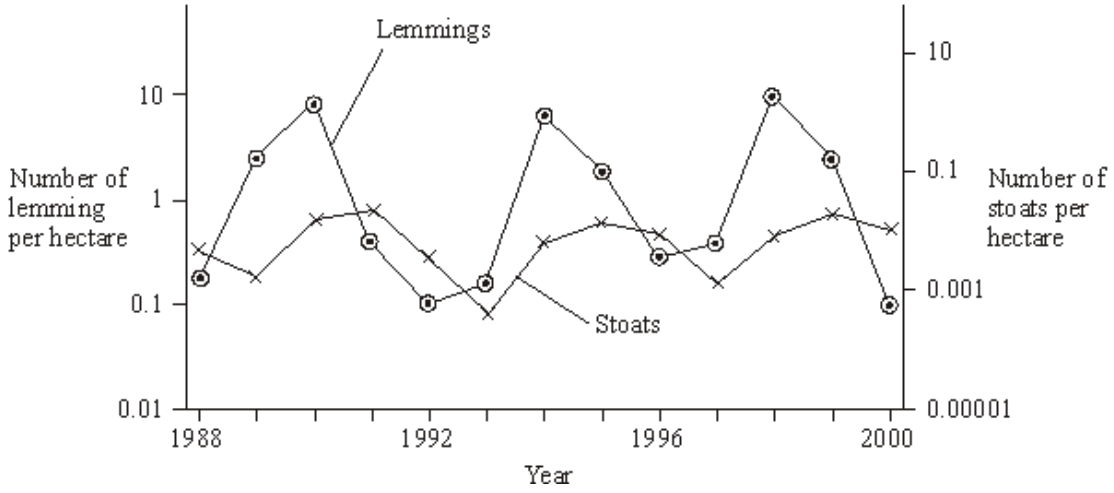
(4)
(Total 8 marks)

Q6. Lemmings are small mammals which live in the Arctic. Their main predator is the stoat, a small carnivorous mammal, which feeds almost entirely on lemmings. The graph shows the changes in the numbers of lemmings and stoats from 1988 to 2000.



(a) Describe and explain the changes which occur in the lemming and stoat populations.

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(6)

S (b) Lemmings often live in isolated populations. From time to time some lemmings move and join other populations. Explain how this movement is important in maintaining genetic variability in lemming populations which have large fluctuations in size.

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(2)

S (c) James Bay is a large ocean bay in northern Canada. It was formed by the melting of glaciers. One species of lemming inhabits the eastern side of James Bay and another species of lemming inhabits the western side. Before the glaciers melted there was only one species of lemming present. Explain how two species of lemming evolved from the original species.

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(4)
(Total 12 marks)

Q7. Coat colour in Labrador dogs is controlled by two different genes. Each gene has a dominant and a recessive allele. The two genes are inherited independently but the effects of the alleles interact to produce three different coat colours. The table gives four genotypes and the phenotypes they produce.

Genotype	Phenotype
BbEe	black
bbEe	chocolate
Bbee	yellow
bbee	yellow

(a) What colour coat would you expect each of the following genotypes to give?

(i) **BBEe** ……

(ii) **bbEE** ……

(2)

(b) A **BbEe** male was crossed with a **bbee** female. Complete the genetic diagram to show the ratio of offspring you would expect.

Parental phenotypes Black male × Yellow female

Parental genotypes **BbEe** **bbee**

Gametes

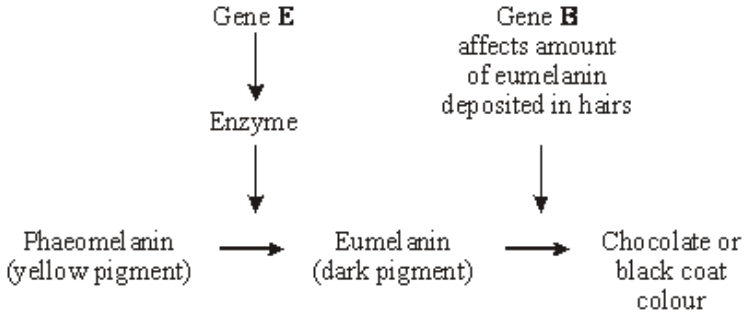
Offspring genotypes

Offspring phenotypes

Ratio of offspring phenotypes

(3)

(c) The yellow coat colour of Labrador dogs is due to the presence of the pigment phaeomelanin in the hairs. The black and chocolate coat colours are due to different amounts of another pigment, eumelanin, deposited in these hairs. The more eumelanin there is, the darker the hair. The diagram shows the action of genes **E** and **B** in producing the different coat colours.



Use this information to explain how

(i) the genotype **bbee** produces a yellow coat colour;

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(2)

(ii) the genotype **BbEe** produces a black coat colour.

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(2)
(Total 9 marks)

Q8. Colour blindness is controlled by a gene on the X chromosome. The allele for colour blindness, $\mathbf{X^b}$, is recessive to the allele for normal colour vision, $\mathbf{X^B}$. The gene controlling the presence of a white streak in the hair is not sex linked, with the allele for the presence of a white streak, **H**, being dominant to the allele for the absence of a white streak, **h**.

(a) Explain why colour blindness is more common in men than in women.

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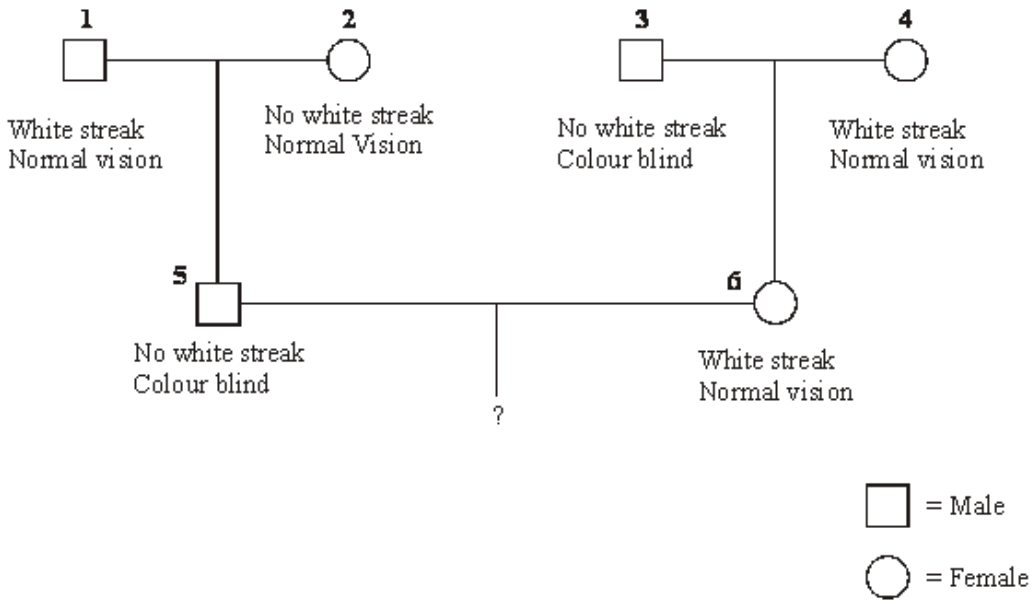
(2)

(b) The diagram shows a family tree in which some of the individuals have colour blindness or have a white streak present in the hair.



(i) What are the genotypes of individuals **5** and **6**?

Individual **5**

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Individual **6**

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(2)

(ii) Give the possible genotypes of the gametes produced by

individual **5**;

.....

individual **6**.

.....

(1)

(iii) What is the probability that the first child of individuals **5** and **6** will be a colour blind boy with a white streak in his hair? Show your working.

Answer .....

(2)

(Total 7 marks)

Q9. (a) A protein found on red blood cells, called antigen G, is coded for by a dominant allele of a gene found on the X chromosome. There is no corresponding gene on the Y chromosome.

The members of one family were tested for the presence of antigen G in the blood. The antigen was found in the daughter, her father and her father's mother, as shown in the genetic diagram below. No other members had the antigen.

	Grandmother (has antigen G)	Grandfather	Grandmother	Grandfather
Genotypes	..... or.....	.....	.....	.....
Gamete genotype	..... or.....	.....	.....	.....

	Father (has antigen G)	Mother
Genotypes	.....	.....
Gamete genotypes	.....	.....

	Daughter (has antigen G)
Genotype	.....

(i) One of the grandmothers has two possible genotypes. Write these on the genetic diagram, using the symbol $\mathbf{X^G}$ to show the presence of the allele for antigen G on the X chromosome, and $\mathbf{X^g}$ for its absence.

(1)

(ii) Complete the rest of the diagram.

(3)

(iii) The mother and father have a son. What is the probability of this son inheriting antigen G? Explain your answer.

Probability .....

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(2)

(b) During meiosis, when the X and Y chromosomes pair up, they do not form a typical bivalent as do other chromosomes. Explain why.

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(2)
(Total 8 marks)

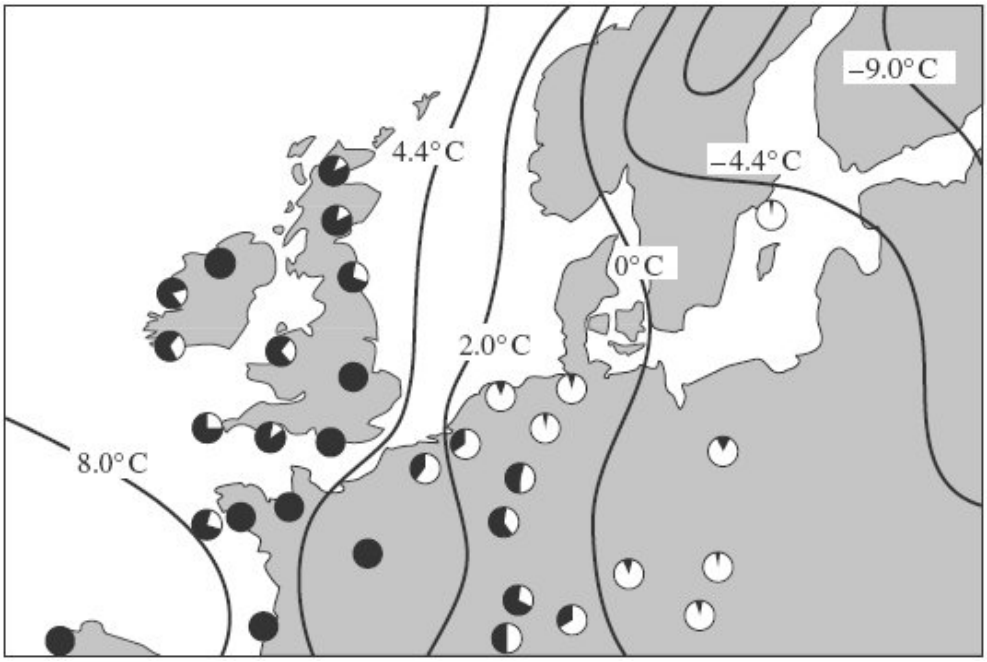
Q10. **S** Clover plants have leaves all through the year. Some clover plants have leaves that produce poisonous hydrogen cyanide gas when damaged. These cyanogenic plants are less likely to be eaten by snails. However, the leaves of these plants can be damaged by frost, resulting in the production of enough hydrogen cyanide to kill the plants. Acyanogenic plants do not produce hydrogen cyanide. This characteristic is genetically controlled.

The map shows the proportions of the two types of plant in populations of clover from different areas in Europe. It also shows isotherms, lines joining places with the same mean January temperature.

Key

Black area represents proportion of plants able to produce cyanide (cyanogenic)

White area represents proportion of plants not able to produce cyanide (acyanogenic)



(a) Explain how different proportions of cyanogenic plants may have evolved in populations in different parts of Europe.

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(4)

(b) Differences in cyanide production may affect the total number of clover plants growing in different areas. Describe how you would use quadrats in an investigation to determine whether or not there is a difference in the number of clover plants in two large areas of equal size.

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(4)
(Total 8 marks)

Q11. In a breed of cattle the **H** allele for the hornless condition is dominant to the **h** allele for the horned condition. In the same breed of cattle the two alleles $\mathbf{C^R}$ (red) and $\mathbf{C^W}$ (white) control coat colour. When red cattle were crossed with white cattle all the offspring were roan. Roan cattle have a mixture of red and white hairs.

(a) Explain what is meant by a *dominant* allele.

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(1)

(b) Name the relationship between the two alleles that control coat colour.

.....

(1)

(c) Horned, roan cattle were crossed with white cattle heterozygous for the hornless condition. Compete the genetic diagram to show the ratio of offspring phenotypes you would expect.

Parental phenotypes Horned, roan × hornless, white

Parental genotypes

Gametes

Offspring genotypes

Offspring phenotypes

Ratio of offspring phenotypes

(4)

(d) The semen of prize dairy bulls may be collected for in vitro fertilisation. The sperms in the semen can be separated so that all the calves produced are of the same sex. The two kinds of sperms differ by about 3% in DNA content.

(i) Explain what causes the sperms of one kind to have 3% more DNA than sperms of the other kind.

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(2)

(ii) Suggest **one** reason why farmers would want the calves to be all of the same sex.

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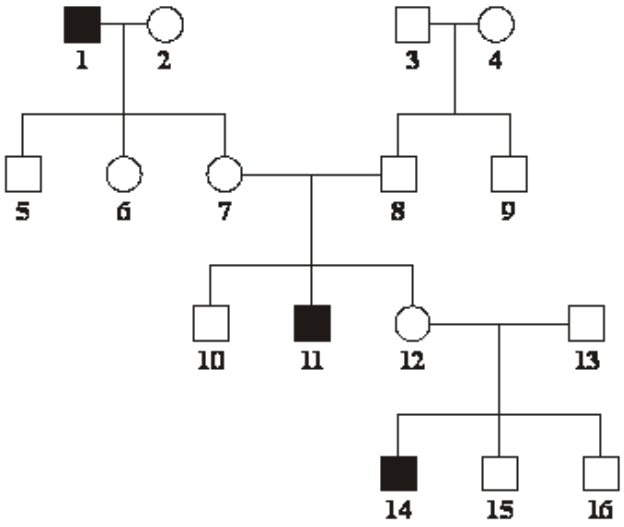
(1)

(Total 9 marks)

Q12.S Red-green colour blindness is caused by a mutation in the gene coding for one of the opsin proteins which are needed for colour vision. The diagram shows the inheritance of red-green colour blindness in one family.



Key

■ = colour-blind male

□ = unaffected male

○ = unaffected female

Person **12** is pregnant with her fourth child. What is the probability that this child will be a male with red-green colour blindness? Explain your answer by drawing a genetic diagram. Use the following symbols

X^R = an X chromosome carrying an allele for normal colour vision

X^r= an X chromosome carrying an allele for red-green colour blindness

Y = a Y chromosome

Probability = ...

(Total 4 marks)

Q13. Warfarin is a substance which inhibits blood clotting. Rats which eat warfarin are killed due to internal bleeding. Some rats are resistant to warfarin as they have the allele $\mathbf{W^R}$.

Rats have three possible genotypes:

$\mathbf{W^RW^R}$ resistant to warfarin
$\mathbf{W^RW^S}$ resistant to warfarin
$\mathbf{W^SW^S}$ susceptible (not resistant) to warfarin.

In addition, rats with the genotype $\mathbf{W^RW^R}$ require very large amounts of vitamin K in their diets. If they do not receive this they will die within a few days due to internal bleeding.

(a) How can resistance suddenly appear in an isolated population of rats which has never before been exposed to warfarin?

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(1)

(b) A population of 240 rats was reared in a laboratory. They were all fed on a diet containing an adequate amount of vitamin K. In this population, 8 rats had the genotype $\mathbf{W^SW^S}$, 176 had the genotype $\mathbf{W^RW^S}$ and 56 had the genotype $\mathbf{W^RW^R}$.

(i) Use these figures to calculate the actual frequency of the allele $\mathbf{W^R}$ in this population. Show your working.

Answer .....

(2)

(ii) The diet of the rats was then changed to include only a small amount of vitamin K. The rats were also given warfarin. How many rats out of the population of 240 would be likely to die within a few days?

.....

(1)

(c) In a population of wild rats, 51% were resistant to warfarin.

(i) Use the Hardy-Weinberg equation to estimate the percentage of rats in this population which would be heterozygous for warfarin resistance. Show your working.

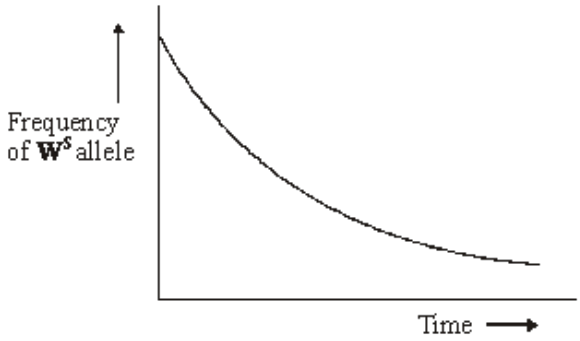
Answer ..... %

(3)

(ii) If all the susceptible rats in this population were killed by warfarin, more susceptible rats would appear in the next generation. Use a genetic diagram to explain how.

(2)

(iii) The graph shows the change in the frequency of the $\mathbf{W^S}$ allele in an area in which warfarin was regularly used. Describe and explain the shape of the curve.



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(4)

(iv) Give **two** assumptions that must be made when using the Hardy-Weinberg equation.

1 ….....

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2 ….....

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(2)

(Total 15 marks)

Q14.S A woman comes from a family with a history of the sex-linked condition haemophilia. A test was carried out to discover the sex of one of the embryos produced by IVF.

(i) Explain how observation of the chromosomes from an embryo cell could enable the sex to be determined.

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(2)

(ii) The mother is known to carry the haemophilia allele. The father does not have haemophilia. What is the probability of their first child having haemophilia? Explain your answer.

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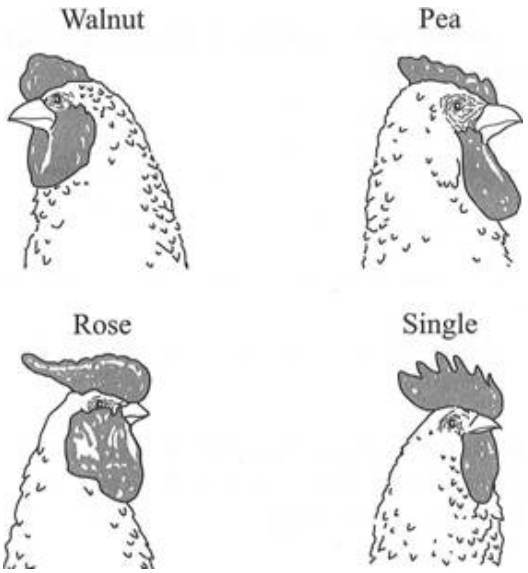
(3)
(Total 5 marks)

Q15. Chickens have a structure on their heads called a comb. The diagram shows four types of comb: walnut, pea, rose and single.



Two genes control the type of comb; each gene has a dominant and a recessive allele. The two genes are inherited independently, but interact to produce the four types of comb.

Genotype	Phenotype
A- B-	Walnut
A- bb	Pea
aa B-	Rose
aa bb	Single

The symbol **-** indicates that either the dominant allele or recessive allele could be present

(a) A male with a pea comb, heterozygous for gene A, was crossed with a rose-combed female, heterozygous for gene B. Complete the genetic diagram to show the offspring expected from this cross.

Phenotypes of parents Pea comb Rose comb

Genotypes of parents ....

Gametes formed ....

Offspring genotypes .....

Ratio of offspring phenotypes .....

.....

(3)

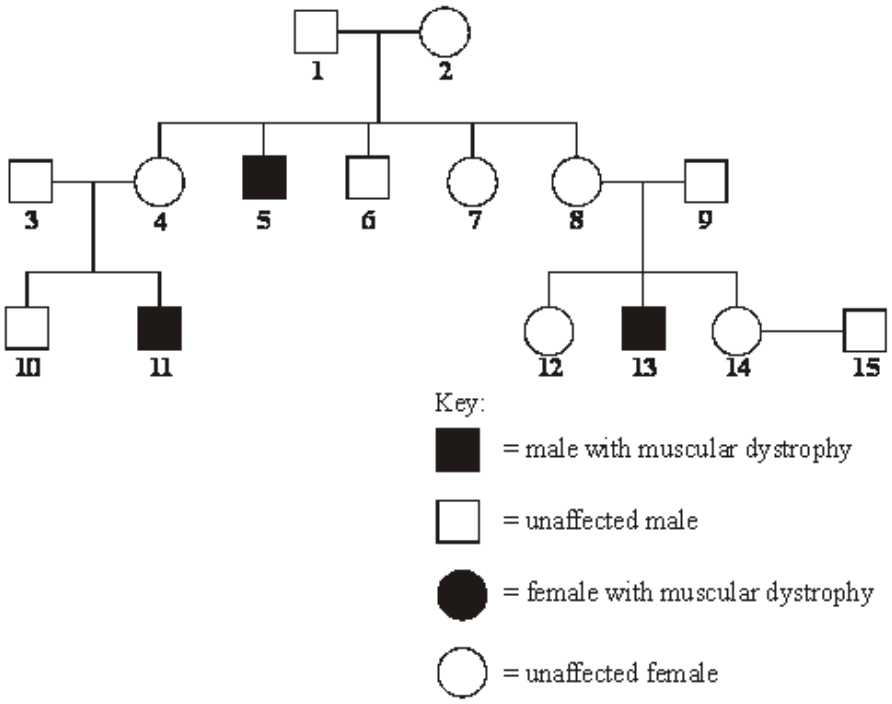
(b) Chickens with rose or single combs made up 36% of one population. Assuming the conditions of the Hardy-Weinberg equilibrium apply, calculate the frequency of allele **a** in this population. Show how you arrived at your answer.

Frequency of allele **a** = ...

(2)

(Total 5 marks)

Q16. Duchenne muscular dystrophy is a sex-linked inherited condition which causes degeneration of muscle tissue. It is caused by a recessive allele. The diagram shows the inheritance of muscular dystrophy in one family.



(a) Give evidence from the diagram which suggests that muscular dystrophy is

(i) sex-linked; .....

.....

(1)

(ii) caused by a recessive allele. .....

.....

(1)

(b) Using the following symbols,

X^D = an X chromosome carrying the normal allele

X^d = an X chromosome carrying the allele for muscular dystrophy

Y = a Y chromosome

give **all** the possible genotypes of each of the following persons.

5 .....

6 .....

7 .....

8 .....

(2)

(c) A blood test shows that person **14** is a carrier of muscular dystrophy. Person **15** has recently married person **14** but as yet they have had no children. What is the probability that their first child will be a male who develops muscular dystrophy?

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(1)
(Total 5 marks)

Q17. Finches are small birds. Fourteen species of finch are found on the Galapagos Islands.

(a) What is a species?

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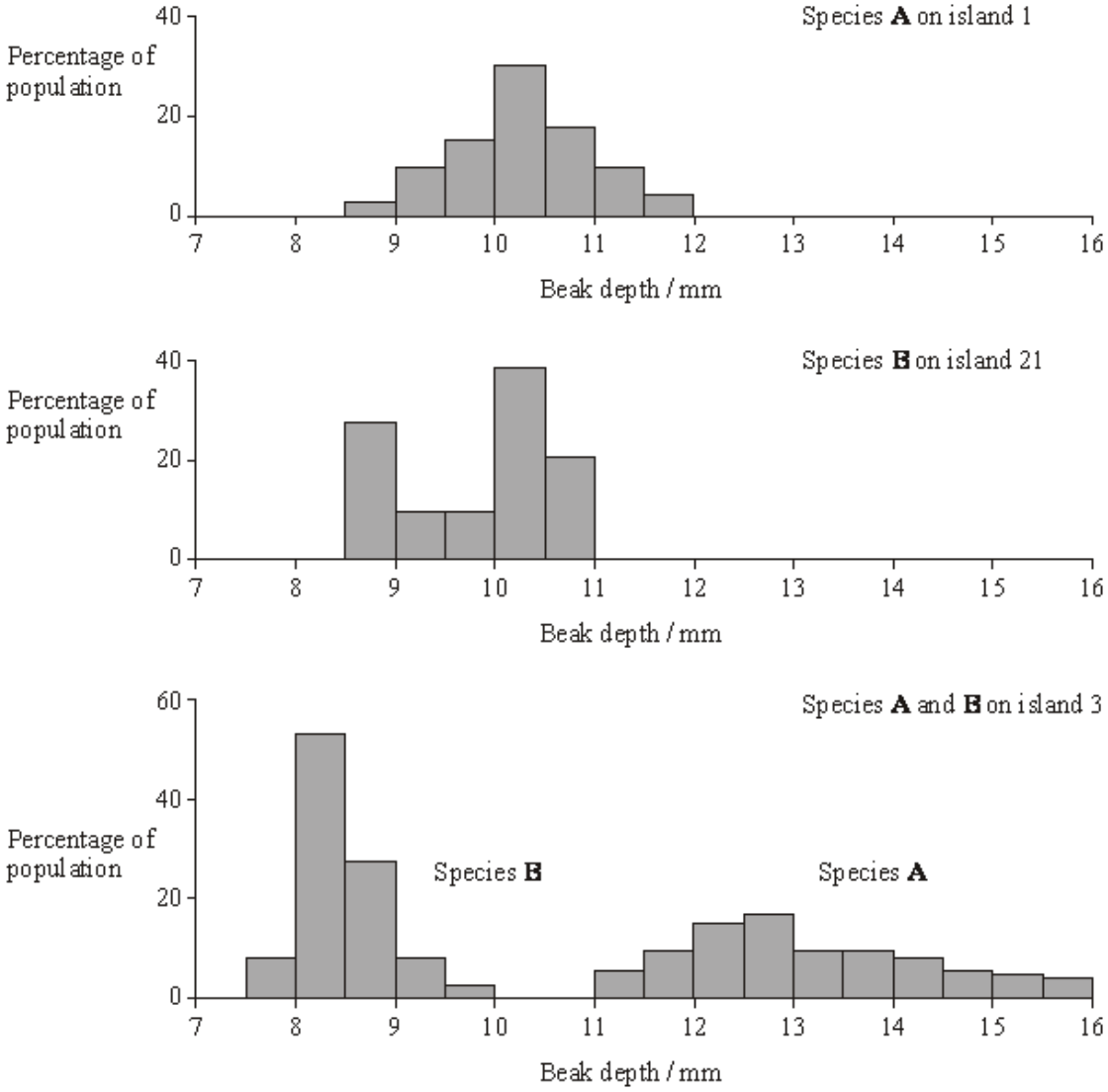
(2)

(b) Measurements were made of the beak depth of two species of finch (species **A** and species **B**) on different islands. Species **A** is found on island 1, species **B** is found on island 2. Both species are found on island 3. They are thought to have colonised island 3 from islands 1 and 2 respectively. The graphs show the ranges of beak depths of the two species on the different islands.



What type of natural selection took place in the populations of both species after they had colonised island 3? Explain your answer.

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(3)
(Total 5 marks)

Q18. Human ABO blood groups are determined by the presence or absence of two antigens (A and B) on the plasma membrane of the red blood cells. The inheritance of these blood groups is controlled by three alleles:

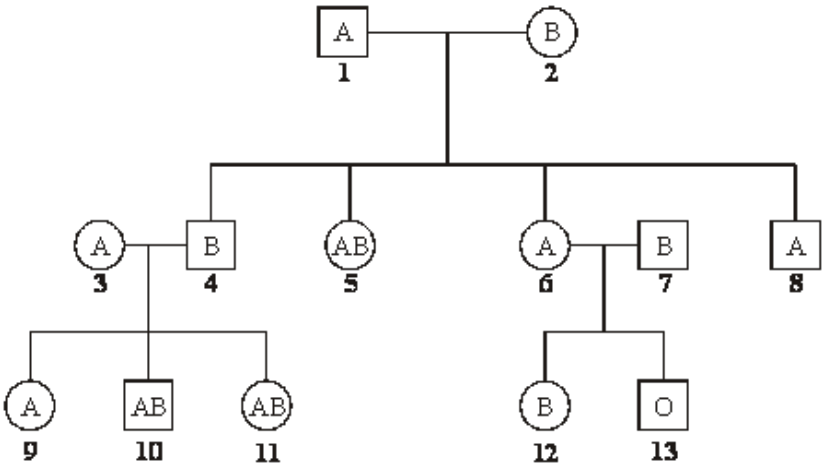
I^A – determines the production of antigen A

I^B – determines the production of antigen B

I^o – determines the production of no antigen

Alleles I^A and I^B are codominant. Allele I^o is recessive to both.

The pedigree shows the pattern of inheritance of these blood groups in a family over three generations.



(a) (i) How many antigen-determining alleles will be present in a white blood cell? Give a reason for your answer.

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(1)

(ii) Which antigen or antigens will be present on the plasma membranes of red blood cells of individual **5**?

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(1)

(b) If individuals **6** and **7** were to have another child, what is the probability that this child would be male and blood group A? Explain your answer.

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(3)
(Total 5 marks)

Q19. The polecat, shown in the drawing, is a wild British mammal. At one time it was very rare. It is now more common and its range is increasing. Scientists carried out a survey of the distribution and status of polecats in Britain during the 1990s.

The first problem that the scientists had was that they needed to distinguish between wild polecats and escaped ferrets. Ferrets are domesticated polecats. They investigated skulls from polecats and ferrets.

They used dial callipers to take skull measurements. They took each measurement six times on six different skulls. They used their measurements to calculate a percentage measurement error using the formula:

$$\text{Percentage measurement error} = \frac{100(1+0.25n)\sigma}{x}$$

where n = number of measurements
σ = standard deviation
x = mean

(a) (i) Use the information from this question to explain the difference between accuracy and reliability.

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(2)

(ii) Unreliable measurements will produce a large percentage measurement error. Use the formula to explain why.

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(2)

Table 1 shows some of the skull measurements obtained by the scientists.

Table 1

Animal	Sex	Number of skulls measured	Mean skull breadth/mm		Cranial volume/cm^3	
			mean	standard deviation	mean	standard deviation
Polecat	Male	90	16.38	1.34	10.15	0.92
Ferret	Male	114	15.56	0.84	8.96	0.93
Polecat	Female	44	15.52	1.04	8.34	0.68
Ferret	Female	47	14.42	0.78	7.03	0.55

(b) (i) Describe **one** way in which you could show whether there was a correlation between mean skull breadth and mean cranial volume.

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(2)

(ii) The scientists found that there was an advantage in taking measurements of skull breadth rather than cranial volume when measuring skull size. Suggest this advantage.

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(1)

(iii) Is skull breadth a reliable way of determining whether a particular skull came from a polecat of from a ferret? Explain the evidence from **Table 1** that supports your answer.

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(3)

(c) In the report that the scientists wrote, they referred to an earlier scientific paper about "Some characteristics of the skulls and skins of the European polecat, the Asiatic polecat and the domestic ferret"
Describe **two** ways in which this earlier paper might have helped the scientists to carry out their work and produce a reliable report.

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(2)

In this survey, the scientists collected the bodies of the dead polecats from roads where they had been killed by passing vehicles. They analysed the stomachs to see what the polecats had eaten. **Table 2** shows the results.

Table 2

Prey	Total number of polecats examined = 83			
	Mass/g	**Mass as percentage of all prey**	**Number of stomachs in which prey item found**	**Percentage of all stomachs in which prey item found**
Rabbit	1063.80	85.4	60	72.3
Rat	22.18	1.8	2	2.4
Other mammals	43.54	3.5	9	10.8
Pigeons	29.45	2.4	3	3.6
Other birds	7.68	0.6	5	5.6
Frogs and toads	56.98	4.6	7	8.4
Fish	0.12	0.01	1	1.2
Earthworms	21.97	1.8	2	2.4
Total	**1245.72**		**89**	

(d) The table shows that a total of 83 stomachs were analysed. Explain why the total for the number of stomachs in which the prey item was found was more than 83.

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(1)

(e) Some farmers regard polecats as pests and claim that they kill poultry and game birds. Use the data to suggest how you would explain to these farmers that they should tolerate polecats on their land.

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(2)
(Total 15 marks)

Q20. A breeder crossed a black male cat with a black female cat on a number of occasions. The female cat produced 8 black kittens and 4 white kittens.

(a) (i) Explain the evidence that the allele for white fur is recessive.

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(1)

(ii) Predict the likely ratio of colours of kittens born to a cross between **this** black male and a white female.

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(1)

(b) The gene controlling coat colour has three alleles. The allele **B** gives black fur, the allele **b** gives chocolate fur and the allele $\mathbf{b}^{i}$ gives cinnamon fur.

- Allele **B** is dominant to both allele **b** and $\mathbf{b}^{i}$.
- Allele **b** is dominant to allele $\mathbf{b}^{i}$.

(i) Complete the table to show the phenotypes of cats with each of the genotypes shown.

Genotype	Phenotype
$\mathbf{Bb}^{i}$	
$\mathbf{bb}^{i}$	
Bb	

(1)

(ii) A chocolate male was crossed several times with a black female.

They produced

- 11 black kittens
- 2 chocolate kittens
- 5 cinnamon kittens.

Using the symbols in part (b), complete the genetic diagram to show the results of this cross.

Parental phenotypes	Chocolate male	Black female	
Parental genotypes	.....	.....	
Gametes	.....	.....	
Offspring genotypes	.....	.....	.....
Offspring phenotypes	Black	Chocolate	Cinnamon

(3)

(iii) The breeder had expected equal numbers of chocolate and cinnamon kittens from the cross between the chocolate male and black female. Explain why the actual numbers were different from those expected.

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(1)

(iv) The breeder wanted to produce a population of cats that would all have chocolate fur. Is this possible? Explain your answer.

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(2)

(Total 9 marks)

Q21. (a) Some antibiotics bind with specific receptors in the plasma membranes of bacteria. The structure of these receptors is determined genetically. Bacteria can become resistant to an antibiotic because a gene mutation results in an altered receptor.

Explain how resistance to an antibiotic could become widespread in a bacterial population following a gene mutation conferring resistance in just one bacterium.

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(5)

(b) Some humans have a genetic resistance to infection. A recessive allele gives increased resistance to infection by the malarial parasite. In a population, the proportion of babies born who are homozygous for this allele is 0.01. Use the Hardy-Weinberg equation to calculate the expected proportion of heterozygotes in this population. Show your working.

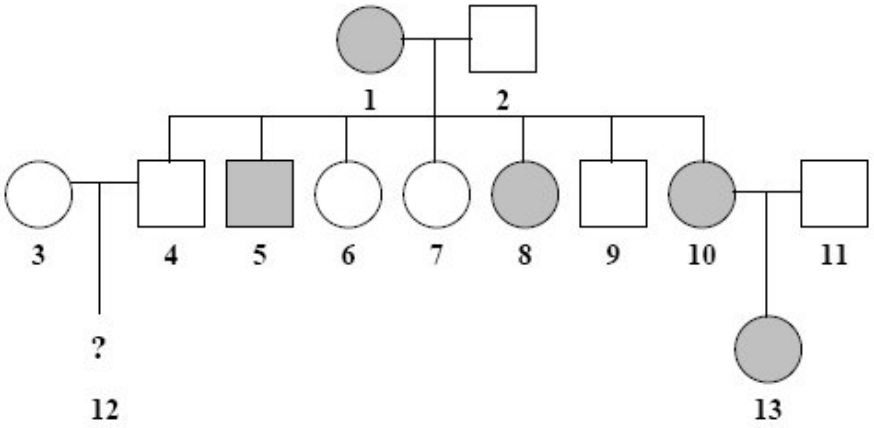
Answer .....

(4)

(Total 9 marks)

Q22. People with night blindness have difficulty seeing in dim light. The allele for night blindness, **N**, is dominant to the allele for normal vision, **n**. These alleles are *not* carried on the sex chromosomes.

The diagram shows part of a family tree showing the inheritance of night blindness



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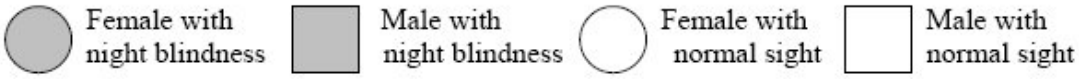

(a) Individual **12** is a boy. What is his phenotype?

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(1)

(b) What is the genotype of individual **1**? Explain the evidence for your answer.

Genotype .....

Evidence.....

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(2)

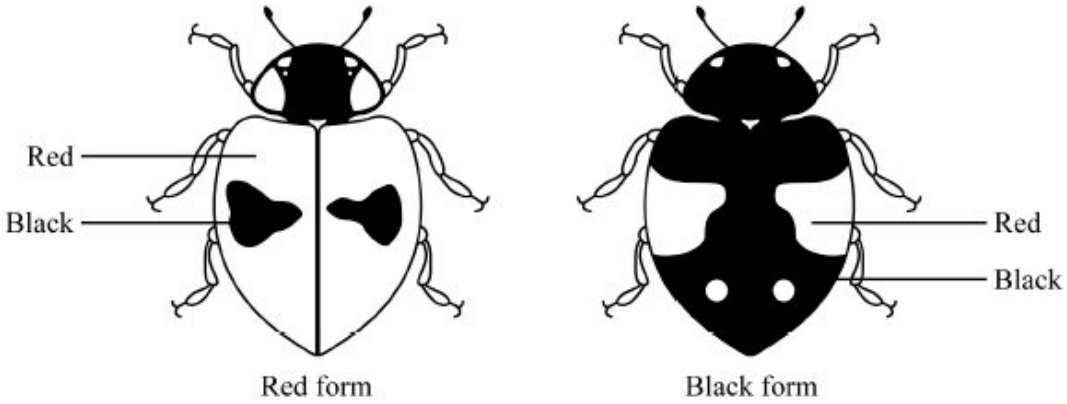
(c) What is the probability that the next child born to individuals **10** and **11** will be a girl with night blindness? Show your working.

Answer.....

(2)

(Total 5 marks)

Q23. The two-spot ladybird is a small beetle. It has a red form and a black form. These two forms are shown in the diagram.



Colour is controlled by a single gene with two alleles. The allele for black, **B**, is dominant to the allele for red, **b**.

Scientists working in Germany compared the number of red and black ladybirds over a ten-year period. They collected random samples of ladybirds from birch trees.

(a) (i) It was important that ladybirds in the samples were collected at random. Explain why.

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(1)

(ii) Suggest **one** method by which the scientists could collect a random sample of ladybirds from the trees.

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(1)

Some of the results from the investigation are shown in the table.

Year	Season	Frequency of b allele
1933	Autumn	0.70
1934	Spring	0.82
1934	Autumn	0.59
1935	Spring	0.76
1935	Autumn	0.57
1936	Spring	0.78

(b) Use the Hardy-Weinberg expression to estimate the percentages of red ladybirds and black lady birds in the Autumn 1933 ladybird population.
Show your working.

Answer ..... red ladybirds

..... black ladybirds

(2)

(c) (i) The evidence from the table shows that the black ladybirds were at a disadvantage and survived less well over winter. Explain this evidence.

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(2)

(ii) The scientists found that black ladybirds heated up more quickly and became active at lower temperatures than red ladybirds. How might this explain the poorer survival of black ladybirds over winter?

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(2)

(Total 8 marks)

Q24. Sea otters were close to extinction at the start of the 20th century. Following a ban on hunting sea otters, the sizes of their populations began to increase. Scientists studied the frequencies of two alleles of a gene in one population of sea otters. The dominant allele, **T**, codes for an enzyme. The other allele, **t**, is recessive and does not produce a functional enzyme.

In a population of sea otters, the allele frequency for the recessive allele, **t**, was found to be 0.2.

(a) (i) Use the Hardy-Weinberg equation to calculate the percentage of homozygous recessive sea otters in this population. Show your working.

Answer ..... %

(2)

(ii) What does the Hardy-Weinberg principle predict about the frequency of the **t** allele after another 10 generations?

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(1)

(b) Several years later, scientists repeated their study on this population. They found that the frequency of the recessive allele had decreased.

(i) A statistical test showed that the difference between the two frequencies of the **t** allele was significant at the P = 0.05 level.

Use the terms **probability** and **chance** to help explain what this means.

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(2)

(ii) What type of natural selection appears to have occurred in this population of sea otters? Explain how this type of selection led to a decrease in the frequency of the recessive allele.

Type of selection .....

Explanation .....

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(2)
(Total 7 marks)

Q25. (a) (i) Explain what is meant by a **recessive** allele.

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(1)

(ii) Explain what is meant by **codominant** alleles.

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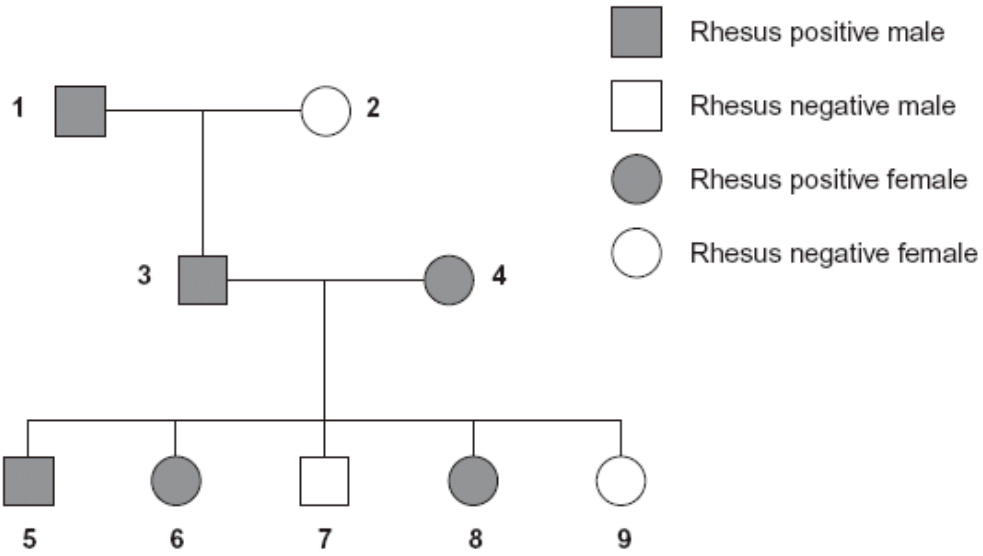
(1)

(b) The Rhesus blood group is genetically controlled. The gene for the Rhesus blood group has two alleles. The allele for Rhesus positive, **R**, is dominant to that for Rhesus negative, **r**. The diagram shows the inheritance of the Rhesus blood group in one family.



(i) Explain **one** piece of evidence from the diagram which shows that the allele for Rhesus positive is dominant.

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(2)

(ii) Explain **one** piece of evidence from the diagram which shows that the gene is **not** on the X chromosome.

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(2)

(c) Sixteen percent of the population of Europe is Rhesus negative. Use the Hardy-Weinberg equation to calculate the percentage of this population that you would expect to be heterozygous for the Rhesus gene.

Show your working.

Answer .....

(3)
(Total 9 marks)

Q26. (a) What does the Hardy–Weinberg principle predict?

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(3)

The table shows the frequencies of some alleles in the population of cats in three cities.

City	Frequency of allele			
	White	Non-agouti	Blotched	Long-haired
Athens	0.001	0.72	0.25	0.50
Paris	0.011	0.71	0.78	0.24
London	0.004	0.76	0.81	0.33

(b) White cats are deaf. Would the Hardy–Weinberg principle hold true for white cats? Explain your answer.

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(2)

(c) What is the evidence from the table that non-agouti and blotched are alleles of different genes?

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(1)

(d) Hair length in cats is determined by a single gene with two alleles. The allele for long hair (h) is recessive. The allele for short hair (H) is dominant.

Use the information in the table and the Hardy–Weinberg equation to estimate the percentage of cats in London that are heterozygous for hair length. Show your working.

Answer .....

(2)

(Total 8 marks)