AQA A-LEVEL · 7402

BIOLOGY



EXAM QUESTION PACK

3.7.1 INHERITANCE AND GENETIC CROSSES

SCORE	PERCENTAGE
/ 429	%

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Q1.

(a) In genetic crosses, the observed phenotypic ratios obtained in the offspring are often **not** the same as the expected ratios.

Suggest **two** reasons why.

1. _____

_____

2. _____

_____

(2)

In tomato plants, the genes for height and for the type of leaf are on the same homologous pair of chromosomes. The allele **T**, for a tall plant, is dominant to the allele **t**, for a dwarf plant. The allele **M**, for normal leaves, is dominant to the allele **m**, for mottled leaves.

A biologist carried out crosses between parent plants heterozygous for both genes and examined the offspring produced. The position of the two alleles for both genes was the same in each parent plant as shown in the diagram. The phenotypes and number of offspring produced are shown in **Table 1**.

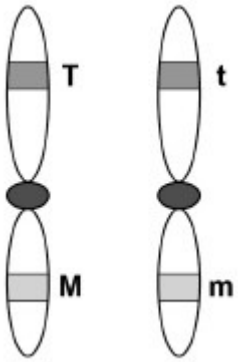


Table 1

Phenotype of offspring	Number of offspring
Tall plants and normal leaves	1860
Tall plants and mottled leaves	68
Dwarf plants and normal leaves	57
Dwarf plants and mottled leaves	580

(b) What would be the genotype of the offspring with dwarf plants and mottled leaves?

_____

(1)

(c) Use the information provided to explain the results in **Table 1**.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(d) Complete **Table 2** to show the expected ratio of phenotypes if the same cross had been carried out but the genes for height of plant and for the type of leaf were on different homologous pairs of chromosomes.

Table 2

Phenotype of offspring	Ratio of offspring

(2)

(Total 8 marks)

Q2.

Lactose is the main sugar in milk and is hydrolysed by the enzyme lactase. Lactase is essential to newborn mammals as milk is their only source of food. Most mammals stop producing lactase when they start feeding on other food sources. Humans are an exception to this because some continue to produce lactase as adults. The ability to continue producing lactase is known as lactase persistence (LP) and is controlled by a dominant allele. A number of hypotheses based on different selection pressures have been put forward to explain LP in humans.

(a) One hypothesis for LP in humans suggests that the selective pressure was related to some human populations farming cattle as a source of milk.

Describe how farming cattle as a source of milk could have led to an increase in LP.

(4)

(b) Use the information provided to explain why the number of people showing LP would **rapidly** increase once selection for this condition had been established.

(2)

(c) Lactase persistence is caused by a mutation in DNA. This mutation does not occur in the gene coding for lactase.

Suggest and explain how this mutation causes LP.

(2)

(Total 8 marks)

Q3.

(a) What is meant by the term phenotype?

_____

_____

_____

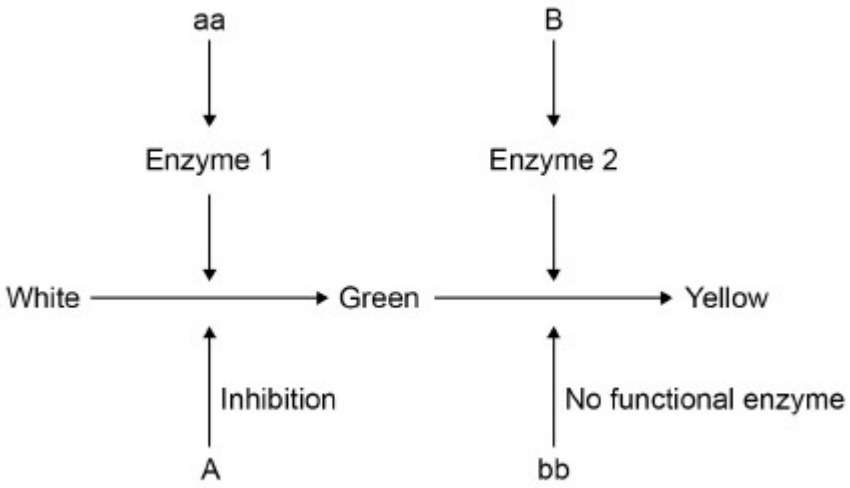
_____

_____

(2)

(b) The inheritance of fruit colour in summer squash plants is controlled by two genes, **A** and **B**. Each gene has two alleles.

The diagram shows the interaction of these two genes in controlling fruit colour in summer squash plants.



Name the type of gene interaction shown in the diagram above.

_____

(1)

(c) What fruit colour would you expect the following genotypes to have?

AAbb _____

aaBB _____

(1)

(d) Genes **A** and **B** are not linked.

Complete the genetic diagram to show all the possible genotypes and the ratio of phenotypes expected in the offspring of this cross.

Genotypes of parents **aabb** × **AaBb**

Genotypes of offspring _____

Phenotypes of offspring _____

Ratio of phenotypes _____

(3)

(e) A population of summer squash plants produced only green and yellow fruit. The percentage of plants producing yellow fruit in this population was 36%.

Use the Hardy−Weinberg equation to calculate the percentage of plants that were heterozygous for gene **B**.

Answer = _____ %

(2)

(Total 9 marks)

Q4.

A student investigated the monohybrid inheritance of eye shape in fruit flies. Two fruit flies with bar (narrow) eyes were crossed. Of the offspring, 1538 had bar eyes and 462 had round (normal) eyes.

(a) Using suitable symbols, give the genotypes of the parents.

Explain your answer.

Genotypes _____

Explanation _____

_____

_____

_____

(2)

(b) The ratio of bar-eyed flies and round-eyed flies in the student's results were not the same as the ratio she had expected.

What ratio of bar-eyed to round-eyed flies was the student expecting?

_____

(1)

(c) Suggest **two** reasons why observed ratios are often **not** the same as expected ratios.

_____

_____

_____

_____

_____

(2)

(d) The student wished to test her results with the ones she had expected.

Which statistical test should she use?

_____

(1)

(e) This fruit fly has another characteristic controlled by a pair of codominant alleles, W^N and W^V.

What is meant by **codominant** alleles?

_____

_____

_____

(1)

(f) There were 850 fruit flies in one population. In this population, 510 fruit flies had the genotype W^NW^N, 255 had the genotype W^NW^V and 85 had the genotype W^VW^V.

Calculate the **actual** frequency of the allele W^V. **Do not** use the Hardy-Weinberg equation in your calculation.

Answer = _____

(1)

(g) In another population of 950 fruit flies, the frequency of the W^V allele was 0.2.

Use the Hardy-Weinberg equation to calculate the number of insects that would be **expected** to have the genotype W^NW^V.

Answer = _____

(2)

(Total 10 marks)

Q5.

(a) In fruit flies, the genes for body colour and wing length are linked. Explain what this means.

_____

_____

(1)

A scientist investigated linkage between the genes for body colour and wing length.
He carried out crosses between fruit flies with grey bodies and long wings and fruit flies with black bodies and short wings.

Figure 1 shows his crosses and the results.

- **G** represents the dominant allele for grey body and **g** represents the recessive allele for black body.
- **N** represents the dominant allele for long wings and **n** represents the recessive allele for short wings.

Figure 1

Phenotype of parents	grey body, long wings	×	black body, short wings
Genotype of parents	**GGNN**		**ggnn**
Genotype of offspring	**GgNn**		
Phenotype of offspring	all grey body, long wings		

These offspring were crossed with flies homozygous for black body and short wings.

The scientist's results are shown in **Figure 2**.

Figure 2

GgNn crossed with **ggnn**

	Grey body, long wings	**Black body, short wings**	**Grey body, short wings**	**Black body, long wings**
Number of offspring	975	963	186	194

(b) Use your knowledge of gene linkage to explain these results.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(c) If these genes were **not** linked, what ratio of phenotypes would the scientist have expected to obtain in the offspring?

_____

_____

(1)

(d) Which statistical test could the scientist use to determine whether his observed results were significantly different from the expected results?

Give the reason for your choice of statistical test.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q6.

Read the following passage carefully.

A large and growing number of disorders are now known to be due to types of mitochondrial disease (MD). MD often affects skeletal muscles, causing muscle weakness.

We get our mitochondria from our mothers, via the fertilised egg cell. Fathers do not pass on mitochondria via their sperm. Some mitochondrial diseases are caused by mutations of mitochondrial genes inside the mitochondria. Most mitochondrial diseases are caused by mutations of genes in the cell nucleus that are involved in the functioning of mitochondria. These mutations of nuclear DNA produce

recessive alleles.

One form of mitochondrial disease is caused by a mutation of a mitochondrial gene that codes for a tRNA. The mutation involves substitution of guanine for adenine in the DNA base sequence. This changes the anticodon on the tRNA. This results in the formation of a non-functional protein in the mitochondrion.

There are a number of ways to try to diagnose whether someone has a mitochondrial disease. One test involves measuring the concentration of lactate in a person's blood after exercise. In someone with MD, the concentration is usually much higher than normal. If the lactate test suggests MD, a small amount of DNA can be extracted from mitochondria and DNA sequencing used to try to find a mutation.

Use information in the passage and your own knowledge to answer the following questions.

(a) Mitochondrial disease (MD) often causes muscle weakness (lines 1–3). Use your knowledge of respiration and muscle contraction to suggest explanations for this effect of MD.

_____

_____

_____

_____

_____

_____

(3)

Two couples, couple **A** and couple **B**, had one or more children affected by a mitochondrial disease. The type of mitochondrial disease was different for each couple.

None of the parents showed signs or symptoms of MD.

- Couple **A** had four children who were all affected by an MD.
- Couple **B** had four children and only one was affected by an MD.

(b) Use the information in lines 5–9 and your knowledge of inheritance to suggest why:

- all of couple **A**'s children had an MD
- only one of couple **B**'s children had an MD.

Couple **A** _____

_____

_____

Couple **B** _____

(4)

(c) Suggest how the change in the anticodon of a tRNA leads to MD (lines 10–13).

(3)

(d) If someone has MD, the concentration of lactate in their blood after exercise is usually much higher than normal (lines 15–17). Suggest why.

(3)

(e) A small amount of DNA can be extracted from mitochondria and DNA sequencing used to try to find a mutation (lines 18–19).

From this sample:

- how would enough DNA be obtained for sequencing?
- how would sequencing allow the identification of a mutation?

(2)

(Total 15 marks)

Q7.

(a) Explain what is meant by the term phenotype.

_____

_____

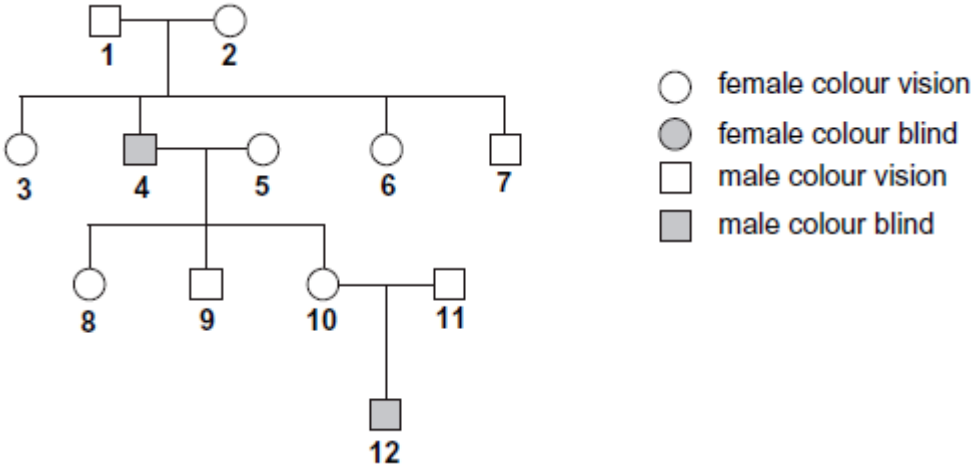
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_____

(2)

(b) One type of colour blindness is controlled by a gene carried on the X chromosome. The allele for this type of colour blindness, **b**, is recessive to the allele for colour vision, **B**.

The diagram shows the phenotypes in a family tree for this sex-linked condition.



(i) Explain **one** piece of evidence from the diagram which shows that colour blindness is recessive.

_____

_____

_____

_____

(2)

(ii) Give the genotype of individual **8**.

_____

(1)

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

The gene controlling tongue-rolling is **not** sex-linked. Individuals **10** and **11** are

both heterozygous for tongue-rolling.

What is the probability that individuals **10** and **11** will produce a male child who is colour blind and a non-tongue roller?

Answer = _____

(2)

(ii) In a population, the frequency of the allele for tongue-rolling, **T**, is 0.4.

Use the Hardy-Weinberg equation to calculate the percentage of people in this population that are heterozygous for tongue-rolling.

Answer = _____ %

(2)

(Total 9 marks)

Q8.

(a) What is the role of ATP in myofibril contraction?

_____

_____

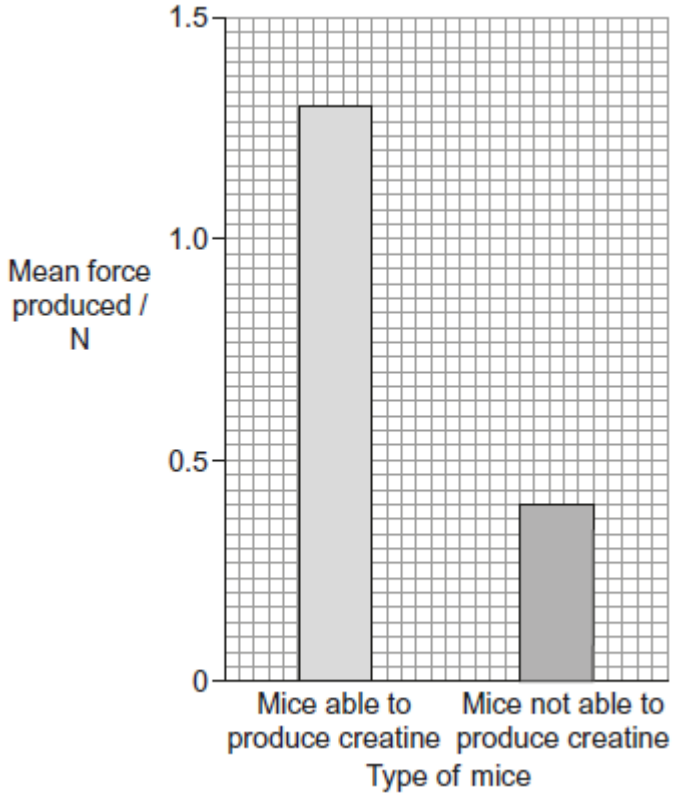
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_____

(2)

(b) Scientists investigated the effect of not being able to produce creatine on the force produced by muscle. They used mice with a mutation that made them not able to produce creatine.
The force produced when these mice gripped with their paws was compared with the force produced by normal mice that were able to produce creatine.

The graph shows the scientists' results.



(i) What was the percentage fall in the mean force produced by mice not able to produce creatine, compared with the normal mice? Show your working.

Answer _____ %

(2)

(ii) Suggest an explanation for these results.

_____

_____

_____

_____

(2)

(c) The mice that were not able to produce creatine were homozygous for a recessive allele of a gene. Mice that are heterozygous for this allele are able to produce forces similar to those of normal mice that are homozygous for the dominant allele of the same gene.

Explain why the heterozygous mice can produce forces similar to those of normal mice.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q9.

In cats, males are XY and females are XX. A gene on the X chromosome controls fur colour in cats. The allele **G** codes for ginger fur and the allele **B** codes for black fur. These alleles are codominant. Heterozygous females have ginger and black patches of fur and their phenotype is described as tortoiseshell.

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

_____

_____

_____

(1)

(b) Male cats with a tortoiseshell phenotype do **not** usually occur. Explain why.

_____

_____

_____

(1)

(c) A tortoiseshell female was crossed with a black male. Use a genetic diagram to show all the possible genotypes and the ratio of phenotypes expected in the offspring of this cross.

Use $\mathbf{X^G}$ to indicate the allele **G** on an X chromosome.
Use $\mathbf{X^B}$ to indicate the allele **B** on an X chromosome.

Genotypes of offspring _____

Phenotypes of offspring _____

Ratio of phenotypes _____

(3)

(d) Polydactyly in cats is an inherited condition in which cats have extra toes. The allele for polydactyly is dominant.

(i) In a population, 19% of cats had extra toes. Use the Hardy-Weinberg equation to calculate the frequency of the recessive allele for this gene in this population.
Show your working.

Answer = _____

(2)

(ii) Some cat breeders select for polydactyly. Describe how this would affect the frequencies of the homozygous genotypes for this gene in their breeding populations over time.

_____

_____

_____

_____

(1)

(Total 8 marks)

Q10.

Some populations of flies are becoming resistant to insecticides intended to kill them.

Scientists developed a method for finding out whether a fly was carrying a recessive allele, **r**, that gives resistance to an insecticide. The dominant allele, **R**, of this gene does not give resistance.

The scientists:
- crossed flies with genotype **RR** with flies with genotype **rr**
- obtained DNA samples from the parents and offspring
- used the same restriction endonuclease enzymes on each sample, to obtain DNA fragments.

(a) Explain why the scientists used the same restriction endonuclease enzymes on each DNA sample.

_____

_____

_____

_____

(2)

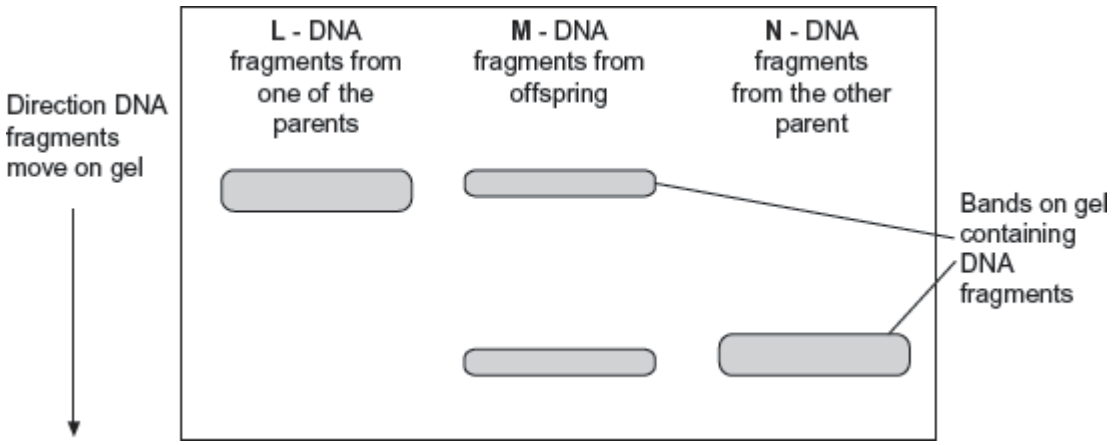
The scientists added two different primers to each sample of DNA fragments for the polymerase chain reaction (PCR).

- Primer A3 only binds to a 195 base-pair fragment from allele **r**.
- Primer A4 only binds to a 135 base-pair fragment from allele **R**.

The scientists separated the DNA fragments produced by the PCR on a gel where shorter fragments move further in a given time.

Their results are shown in **Figure 1**.

Figure 1



(b) Explain why primer A3 and primer A4 only bind to specific DNA fragments.

_____

_____

_____

_____

(2)

(c) Use all the information given to explain the results in **Figure 1**.

_____

_____

_____

_____

_____

_____

(3)

(d) The scientists wanted to know on which chromosome the gene with alleles **R** and **r** was located. From the flies with genotype **RR**, they obtained cells that were in mitosis and added a labelled DNA probe specific for allele **R**. They then looked at the cells under an optical microscope.

Explain why they used cells that were in mitosis.

_____

_____

_____

_____

(2)

(e) Another group of scientists thought that pesticide resistance in some flies was related to increased activity of an enzyme called P450 monooxygenase (PM). This enzyme breaks down insecticides.

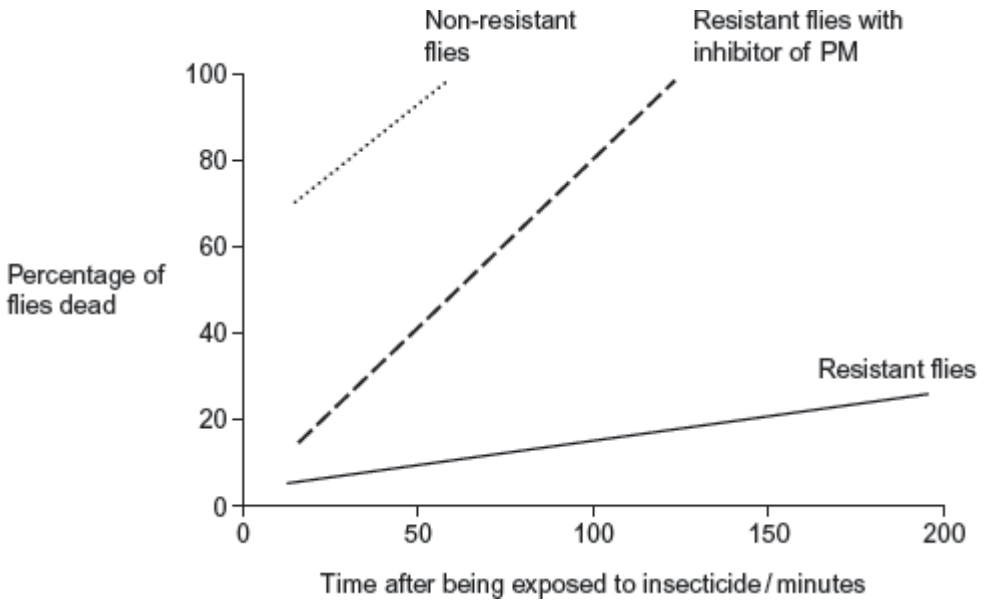
The scientists obtained large numbers of resistant and non-resistant flies. They then set up the following experiments.

- Non-resistant flies exposed to insecticide.
- Resistant flies exposed to insecticide.
- Resistant flies treated with an inhibitor of PM and then exposed to insecticide.

They then determined the percentage of flies that were dead at different times after being exposed to insecticide.

Figure 2 shows their results.

Figure 2



(i) Explain why the scientists carried out the control experiment with the non-resistant flies.

_____

_____

_____

_____

_____

(2)

(ii) The scientists concluded that the resistance of the flies to the insecticide is partly due to increased activity of PM but other factors are also involved.

Explain how these data support this conclusion.

_____

_____

_____

_____

_____

_____

(4)

(Total 15 marks)

Q11.

In birds, **males are XX** and **females are XY**.

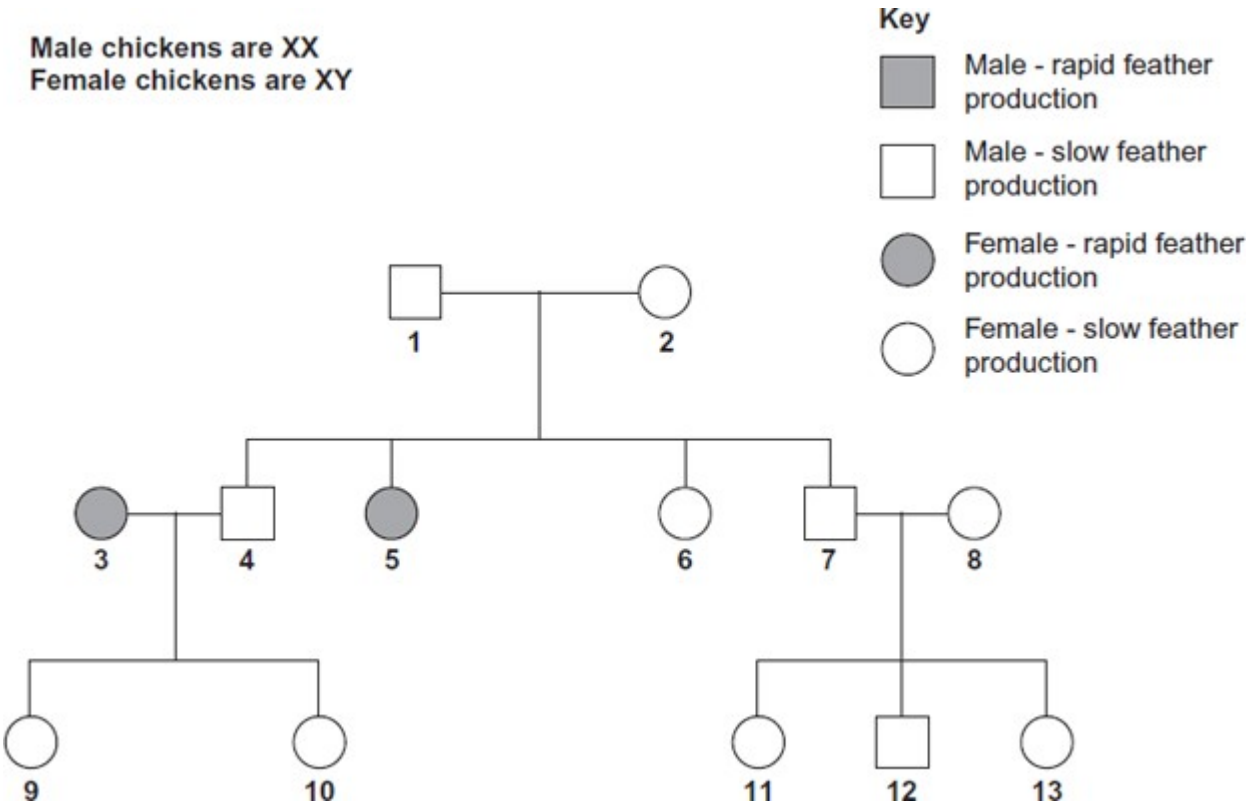
(a) Use this information to explain why recessive, sex-linked characteristics are more common in female birds than in male birds.

_____

_____

(1)

(b) In chickens, a gene on the X chromosome controls the rate of feather production. The allele for slow feather production, **F**, is dominant to the allele for rapid feather production, **f**. The following figure shows the results produced from crosses carried out by a farmer.



(i) Explain **one** piece of evidence from the figure which shows that the allele for rapid feather production is recessive.

_____

_____

_____

_____

(2)

(ii) Give all the possible genotypes of the following chickens from the figure.

Chicken 5 _____

Chicken 7 _____

(2)

(iii) A cross between two chickens produced four offspring. Two of these were males with rapid feather production and two were females with slow feather production. Give the genotypes of the parents.

_____

(1)

(c) Feather colour in one species of chicken is controlled by a pair of codominant alleles which are **not** sex-linked. The allele $\mathbf{C^B}$ codes for black feathers and the allele $\mathbf{C^W}$ codes for white feathers. Heterozygous chickens are blue-feathered.

On a farm, 4% of the chickens were black-feathered. Use the Hardy-Weinberg equation to calculate the percentage of this population that you would expect to be blue-feathered. Show your working.

Answer _____ %

(3)

(Total 9 marks)

Q12.

(a) Explain what is meant by the term phenotype.

_____

_____

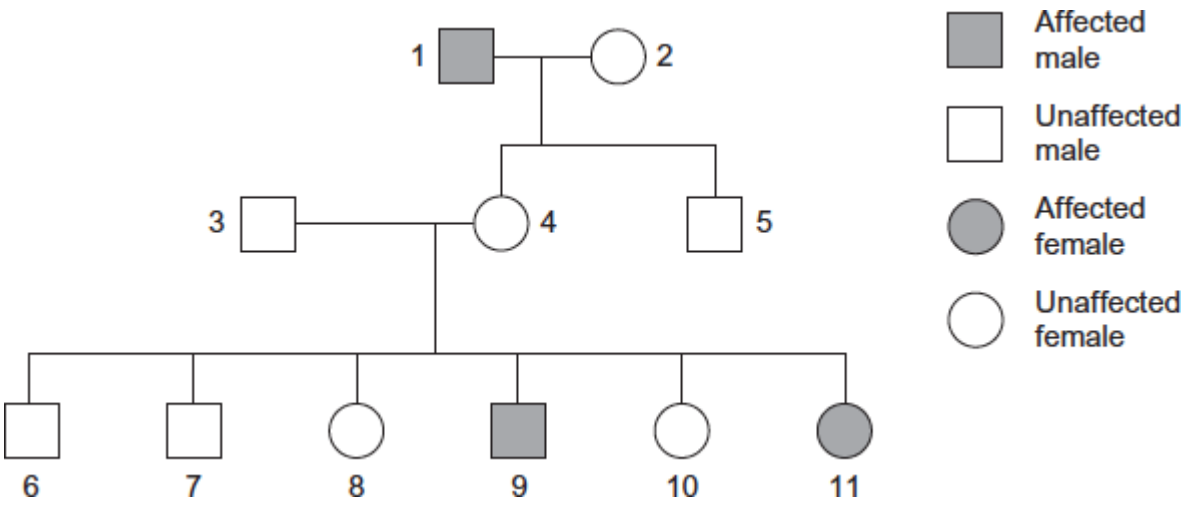
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_____

_____

(2)

(b) Tay-Sachs disease is a human inherited disorder. Sufferers of this disease often die during childhood. The allele for Tay-Sachs disease **t,** is recessive to allele **T**, present in unaffected individuals. The diagram shows the inheritance of Tay-Sachs in one family.



(i) Explain **one** piece of evidence from the diagram which proves that the allele for Tay-Sachs disease is recessive.

_____

_____

_____

_____

_____

(2)

(ii) Explain **one** piece of evidence from the diagram which proves that the allele for Tay-Sachs disease is **not** on the X chromosome.

_____

_____

_____

_____

_____

(2)

(c) (i) In a human population, one in every 1000 children born had Tay-Sachs disease. Use the Hardy-Weinberg equation to calculate the percentage of this population you would expect to be heterozygous for this gene. Show your working.

Answer = _____ %

(3)

(ii) The actual percentage of heterozygotes is likely to be lower in future generations than the answer to part (c)(i). Explain why.

_____

_____

_____

(1)

(Total 10 marks)

Q13.

Researchers investigated some characteristics of people from different parts of England. In the north of England they selected 200 people and recorded their phenotypes for three different characteristics.

Their results are shown in the figure below.

Phenotype produced by dominant allele	Number of people	Phenotype produced by recessive allele	Number of people

Tongue roller	131	Non-tongue roller	58
Right-handed	182	Left-handed	14
Straight thumb	142	Hitch-hiker thumb	50

(a) Calculate the ratio of straight thumb to hitch-hiker thumb in this study.

Ratio = _____

(1)

(b) The numbers for the tongue rolling and thumb characteristics do not add up to 200.
For each characteristic suggest **one** reason why the numbers do **not** add up to 200.

Tongue rolling _____

_____

_____

Thumb _____

_____

_____

(2)

(c) One student looked at the researchers' results and concluded that 91% of people in the UK are right-handed.
Do you agree with this conclusion? Give reasons for your answer.

_____

_____

_____

_____

_____

(2)

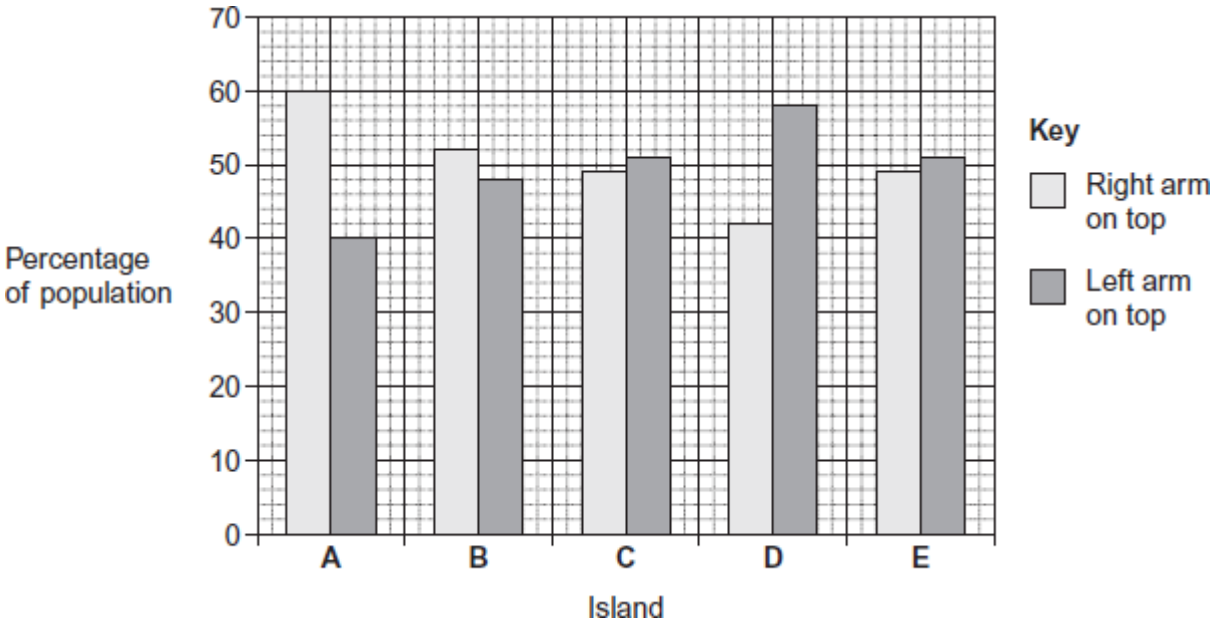
(Total 5 marks)

Q14.

When most people fold their arms, they either always have their left arm on top, **L**, or always have their right arm on top, **R**. A geneticist investigated this characteristic on five small islands, **A, B, C, D** and **E**.

Her results are shown in **Figure 1**.

Figure 1



On one of the islands she recorded the arm-folding characteristics of parents and their children.

These results are shown in **Figure 2**.

Figure 2

Arm-folding of parents	Arm-folding of the children / %	
	Right arm on top, R	Left arm on top, L
R and **R**	41	59
R and **L**	45	55
L and **L**	44	56

The geneticist concluded that arm-folding is not determined by a single gene with a dominant allele and a recessive allele.

(a) The geneticist investigated arm-folding on five small islands.

(i) Use information from **Figure 1** to describe the results she obtained.

_____

_____

_____

_____

_____

(2)

(ii) Suggest advantages of using island populations in this investigation.

_____

_____

_____

_____

_____

(2)

(b) The geneticist concluded that arm-folding is **not** determined by a single gene with a dominant allele and a recessive allele.

Use information from **Figure 2** to explain why she reached this conclusion.

_____

_____

_____

_____

_____

_____

(3)

(c) In another study, the geneticist investigated arm-folding in genetically identical twins. Data from this study supported her conclusion from the island study.

Suggest the evidence she found that supported her conclusion.

_____

_____

_____

(1)

(Total 8 marks)

Q15.

The fruit fly is a useful organism for studying genetic crosses. Female fruit flies are approximately 2.5 mm long. Males are smaller and possess a distinct black patch on their bodies. Females lay up to 400 eggs which develop into adults in 7 to 14 days. Fruit flies will survive and breed in small flasks containing a simple nutrient medium consisting mainly of sugars.

(a) Use this information to explain **two** reasons why the fruit fly is a useful organism for studying genetic crosses.

1. _____

_____

2. _____

_____

(2)

(b) Male fruit flies have the sex chromosomes XY and the females have XX. In the fruit fly, a gene for eye colour is carried on the X chromosome. The allele for red eyes, **R**, is dominant to the allele for white eyes, **r**. The genetic diagram shows a cross between two fruit flies.

(i) Complete the genetic diagram for this cross.

Phenotypes of parents	red-eyed female		white-eyed male
Genotype of parents	_____	×	_____
Gametes	_____and_____		_____and_____
Phenotypes of offspring	red-eyed females	and	red-eyed males
Genotype of offspring	_____		_____

(3)

(ii) The number of red-eyed females and red-eyed males in the offspring was counted. The observed ratio of red-eyed females to red-eyed males was similar to, but not the same as, the expected ratio. Suggest **one** reason why observed ratios are often **not** the same as expected ratios.

_____

_____

_____

(1)

(c) Male fruit flies are more likely than female fruit flies to show a phenotype produced by a recessive allele carried on the X chromosome. Explain why.

_____

_____

_____

_____

_____

(2)

(Total 8 marks)

Q16.

In a species of snail, shell colour is controlled by a gene with three alleles. The shell may be brown, pink or yellow. The allele for brown, $\mathbf{C^B}$, is dominant to the other two alleles. The allele for pink, $\mathbf{C^P}$, is dominant to the allele for yellow, $\mathbf{C^Y}$.

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

_____

_____

_____

(1)

(b) Give **all** the genotypes which would result in a brown-shelled snail.

_____

(1)

(c) A cross between two pink-shelled snails produced only pink-shelled and yellow-shelled snails. Use a genetic diagram to explain why.

(3)

(d) The shells of this snail may be unbanded or banded. The absence or presence of bands is controlled by a single gene with two alleles. The allele for unbanded, **B**, is dominant to the allele for banded, **b**.

A population of snails contained 51% unbanded snails. Use the Hardy-Weinberg equation to calculate the percentage of this population that you would expect to be heterozygous for this gene. Show your working.

Answer _____ %

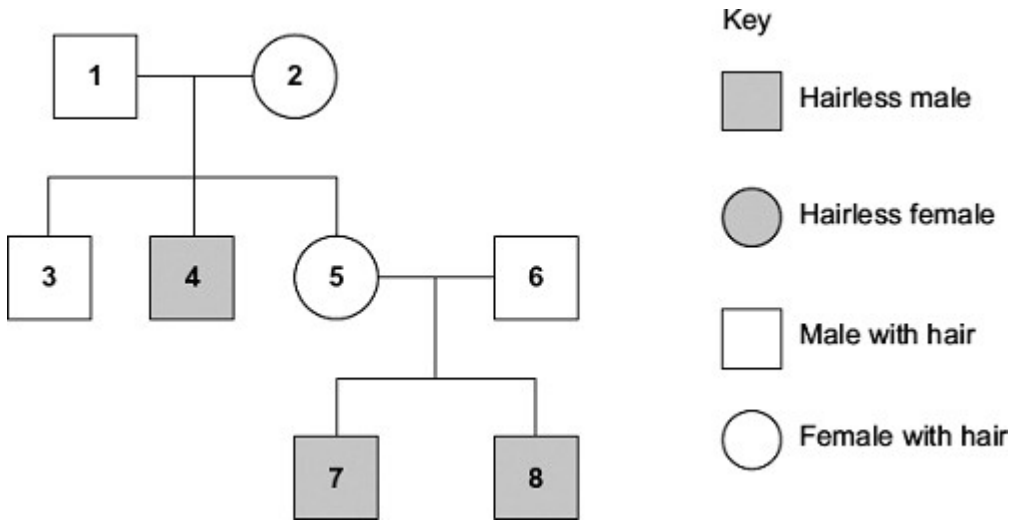
(3)

(Total 8 marks)

Q17.

A single gene controls the presence of hair on the skin of cattle. The gene is carried on the X chromosome. Its dominant allele causes hair to be present on the skin and its recessive allele causes hairlessness.

The diagram shows the pattern of inheritance of these alleles in a group of cattle.



(a) Use evidence from the diagram to explain

(i) that hairlessness is caused by a recessive allele

_____

_____

_____

_____

_____

(2)

(ii) that hairlessness is caused by a gene on the X chromosome.

_____

_____

(1)

(b) What is the probability of the next calf born to animals **5** and **6** being hairless? Complete the genetic diagram to show how you arrived at your answer.

Phenotypes of parents	Female with hair	Male with hair
Genotypes of parents	_____	_____
Gametes	_____	_____

Genotypes of offspring _____

Phenotypes of offspring _____

Probability of next calf being hairless _____

(4)

(Total 7 marks)

Q18.

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.

_____

_____

(1)

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

_____

(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 **b^{i}** gives cinnamon fur.

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

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

Genotype	Phenotype
Bb^{i}	
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.

_____

_____

_____

(1)

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

_____

_____

_____

_____

_____

(2)

(Total 9 marks)

Q19.

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

_____

_____

_____

(1)

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

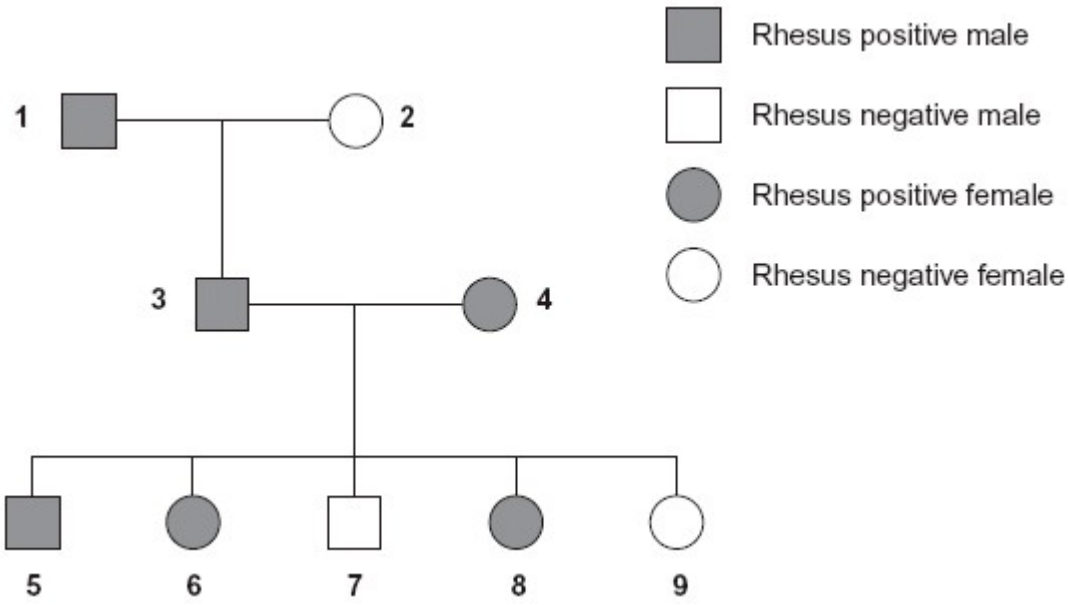
_____

_____

_____

(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.

_____

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

_____

(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.

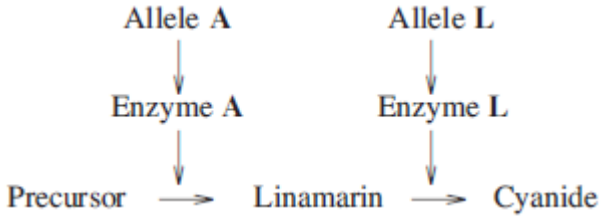
Answer _____

(3)

(Total 9 marks)

Q20.

Cyanide is a poisonous substance. Cyanogenic clover plants produce cyanide when their tissues are damaged. The ability to produce cyanide is controlled by genes at loci on two different chromosomes. The dominant allele, **A**, of one gene controls the production of an enzyme which converts a precursor to linamarin. The dominant allele, **L**, of the second gene controls the production of an enzyme which converts linamarin to cyanide. This is summarised in the diagram.



(a) Acyanogenic clover plants cannot produce cyanide. Explain why a plant with the genotype **aaLl** cannot produce cyanide.

_____

_____

(1)

(b) A clover plant has the genotype **AaLl**.

(i) Give the genotypes of the male gametes which this plant can produce.

_____

(1)

(ii) Explain how meiosis results in this plant producing gametes with these genotypes.

_____

_____

_____

_____

(2)

(c) Two plants, heterozygous for both of these pairs of alleles, were crossed. What proportion of the plants produced from this cross would you expect to be acyanogenic but able to produce linamarin? Use a genetic diagram to explain your answer.

(3)

In an investigation, cyanogenic and acyanogenic plants were grown together in pots. Slugs were placed in each pot and records were kept of the number of leaves damaged by the feeding of the slugs over a period of 7 days. The results are shown in **Table 1**.

Table 1

	Undamaged	**Damaged**
Cyanogenic plants	160	120
Acyanogenic plants	88	192

(d) A x^2 test was carried out on the results.

(i) Suggest the null hypothesis that was tested.

_____

_____

(1)

(ii) x^2 was calculated. When this value was looked up in a table, it was found to correspond to a probability of less than 0.05. What conclusion can you draw from this?

_____

_____

_____

_____

_____

_____

(3)

A second investigation was carried out in a field of grass which had been undisturbed for many years. **Table 2** shows the population density of slugs and the numbers of cyanogenic and acyanogenic clover plants at various places in the field.

Table 2

Population density of slugs	Number of acyanogenic clover plants per m^2	Number of cyanogenic clover plants per m^2
Very low	26	10
Low	17	26
High	0	10
Very high	0	5

(e) Explain the proportions of the two types of clover plant in different parts of the field.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 15 marks)

Q21.

(a) Meiosis results in cells that have the haploid number of chromosomes and show genetic variation. Explain how.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(b) In mice, two genes affecting coat colour are on different chromosomes.
One gene controls whether there is any black pigment in the hairs. The dominant allele of this gene, **B**, results in black fur. The recessive allele, **b**, results in white fur. The second gene controls banding of the fur. The dominant allele, **A**, causes a yellow band to develop on each hair. The resulting coat colour is called agouti. The recessive allele, **a**, results in hairs with no bands on them. This gene has no effect on mice with white fur; white mice do not develop bands, even if they have the **A** allele.

Breeders performed many crosses in which agouti mice were crossed with white mice, homozygous for both genes. They expected agouti, black and white mice in the offspring in a 1 : 1 : 2 ratio.

(i) Complete the genetic diagram to show how this ratio of phenotypes would be produced.

Parental phenotypes	Agouti	White
Parental genotypes		
Gamete genotypes		
Offspring genotypes		
Offspring phenotypes		

(4)

(ii) The actual numbers of offspring with each phenotype were

Agouti	34
Black	35
White	51

The x^2 test can be used to test the hypothesis that there is no significant difference between these results and the expected 1 : 1 : 2 ratio. Complete the table to calculate the value of x^2 for these results.

Colour of offspring	Observed (O)	Expected (E)	(O - E)	$(O - E)^2$	$\frac{(O-E)^2}{E}$
Agouti	34				
Black	35				
White	51				
			$\sum \frac{(O-E)^2}{E}$ =		

(2)

(iii) The table shows values for x^2 at different levels of probability and for different degrees of freedom.

Degrees of freedom	Probability, p				
	0.2	**0.1**	**0.05**	**0.02**	**0.01**
1	1.64	2.71	3.84	5.41	6.64
2	3.22	4.61	5.99	7.82	9.21
3	4.64	6.25	7.82	9.84	11.35
4	5.99	7.78	9.49	11.67	13.28
5	7.29	9.24	11.07	13.39	15.09

What should the breeders conclude about the significance of their results? Explain your answer.

_____

_____

_____

_____

_____

_____

(3)

(Total 15 marks)

Q22.

(a) The guinea pig, *Cavia porcellus*, is a small mammal. Complete the table to show the classification of the guinea pig.

Kingdom	
	Chordata
	Mammalia
	Rodentia
Family	Caviidae
Genus	
Species	

(2)

(b) In South America, there are several species of guinea pig. They are thought to have arisen by sympatric speciation.
Explain how sympatric speciation may have occurred.

_____

_____

_____

_____

_____

_____

(3)

(c) In guinea pigs, hair length and hair colour are controlled by two genes on different chromosomes. The hair may be either long or short and its colour either black or brown.

A male guinea pig and a female guinea pig both had short, black hair. The male was homozygous for hair length, and the female was homozygous for hair colour. Repeated crossings of these two guinea pigs resulted in offspring of four different genotypes, all of which had short, black hair.

Complete the genetic diagram to explain these results. Write in the box the symbols you will use to represent the alleles.

Allele for short hair = _____	Allele for long hair = _____

Allele for black hair = _____	Allele for brown hair = _____

	Male	Female
Parental phenotypes	Short, black hair	Short, black hair
Parental genotypes	_____	_____
Gamete genotypes	_____	_____
Offspring genotypes	_____	
Offspring phenotypes	Short, black hair	

(4)

(d) In another investigation, the same female guinea pig was twice mated with another male which had long, brown hair. Of the 14 offspring, 10 had short, black hair and 4 had long, black hair. The investigators expected equal numbers of offspring with these two phenotypes. They used a χ^2 test to determine whether the observed results fitted the expected 1:1 ratio.

Give a suitable null hypothesis for the investigation.

_____

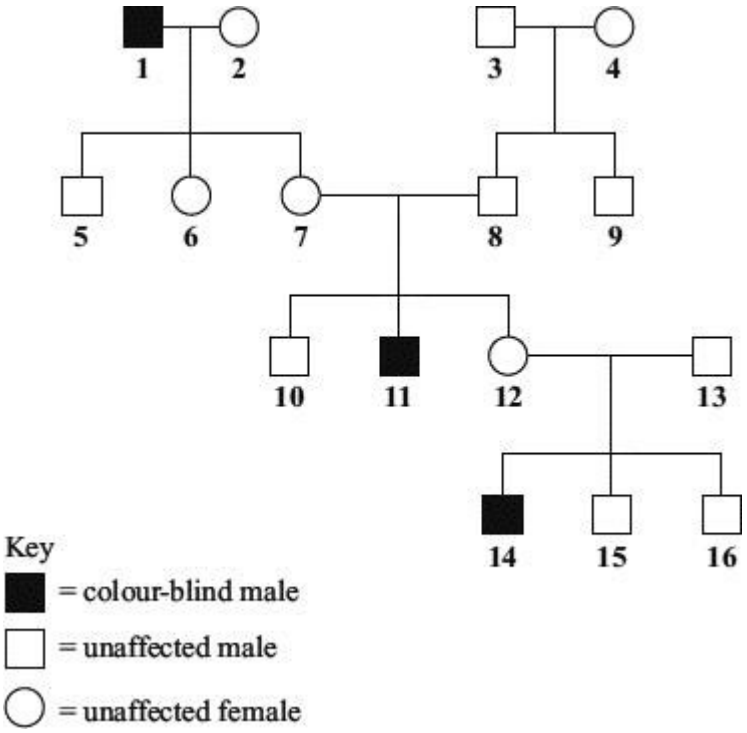
_____

(1)

(Total 10 marks)

Q23.

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.



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 = _____

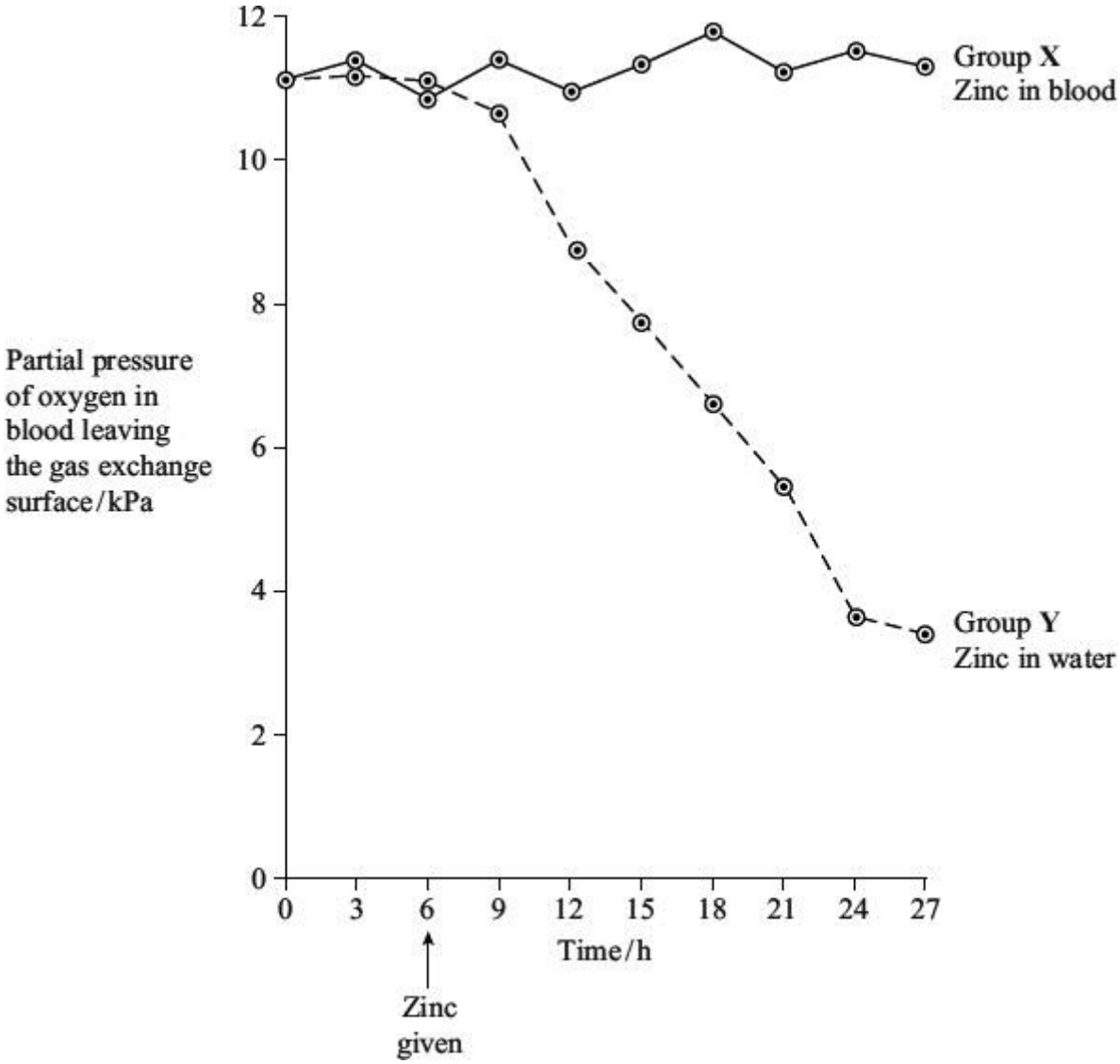
(Total 4 marks)

Q24.

Ions of metals such as zinc often pollute rivers. The effect of zinc ions on gas exchange and respiration in fish was investigated. Fish were kept in tanks of water in a laboratory.

The fish in one group (**X**) had a solution of a zinc compound injected directly into their blood and were then put in a tank of zinc-free water. A second group (**Y**) was not injected but had the solution of the zinc compound added to the water in the tank.

The partial pressure of oxygen in the blood of both groups of fish was then monitored. The results are shown in the graph.



(a) During this investigation, the water temperature in the tanks was kept constant. Explain why changes in the water temperature might lead to the results of the investigation being unreliable.

_____

_____

(1)

(b) The results from the two groups were compared using a statistical test.

(i) Suggest a null hypothesis that could be tested.

_____

(1)

(ii) Explain why it is important to use a statistical test in analysing the results of this investigation.

_____

_____

_____

_____

(2)

(c) Two suggestions were made to explain the results shown in the graph.

A Zinc ions reduce the rate at which oxygen is taken up from the water and passes into the blood.

B Zinc ions reduce the ability of haemoglobin to transport oxygen.

Which of these suggestions is the more likely? Explain the evidence from the graph that supports your answer.

_____

_____

_____

_____

(2)

(d) During the investigation, the pH of the blood was also monitored. It decreased in group **Y**. Suggest an explanation for this decrease in pH.

_____

_____

_____

_____

_____

_____

(3)

(e) Leaves were collected from sycamore trees growing in a polluted wood and the

concentration of some metal ions in samples of these leaves was measured. Woodlice were then fed with the leaves. After 20 weeks, the concentration of the ions in the bodies of the woodlice was measured. Some of the results are shown in the table.

	Concentration of ions / μg g^{-1}			
	Copper	Cadmium	Zinc	Lead
Leaves	52	26	1430	908
Woodlice	1130	525	1370	132

(i) Which of the elements shown in the table is concentrated most by the woodlice? Use suitable calculations to support your answer.

(2)

(ii) Suggest what happens to most of the lead ions in the leaves eaten by the woodlice.

_____

_____

(1)

(iii) Explain the difference in the copper ion concentration between the leaves and the woodlice.

_____

_____

_____

_____

(2)

(f) Yorkshire fog is a species of grass. Two varieties of Yorkshire fog were studied. One variety was tolerant to arsenic, while the other variety was not. In a series of investigations, it was found that

- Arsenic-tolerant plants grow in soil which contains a high concentration of arsenic.
- Arsenic-tolerant plants growing in soil containing high concentrations of arsenic and phosphorus-containing compounds have very low concentrations of arsenic in their cells. They also have low concentrations of phosphates in their cells. Arsenic and phosphorus are chemically similar.
- Plants that are not tolerant to arsenic grow poorly on soil which has a high

concentration of both arsenic and phosphorus-containing compounds.

- Tolerance to arsenic in Yorkshire fog is caused by a single gene with the allele, **a**, for tolerance recessive to the allele, **A**, for non-tolerance.

(i) What caused the allele for tolerance to first arise?

_____

_____

(1)

(ii) Give **two** functions of phosphates in plant cells.

1. _____

_____

2. _____

_____

(2)

(iii) Arsenic-tolerant Yorkshire fog plants are very rare in areas with low concentrations of arsenic in the soil, even where the soil has a high concentration of phosphate. Explain why they are unable to compete in these conditions with plants that are not tolerant to arsenic.

_____

_____

_____

_____

_____

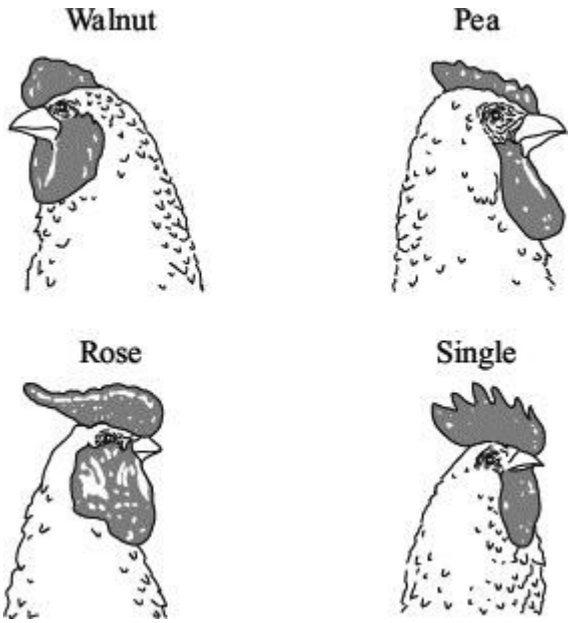
_____

(3)

(Total 20 marks)

Q25.

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)

Q26.

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:

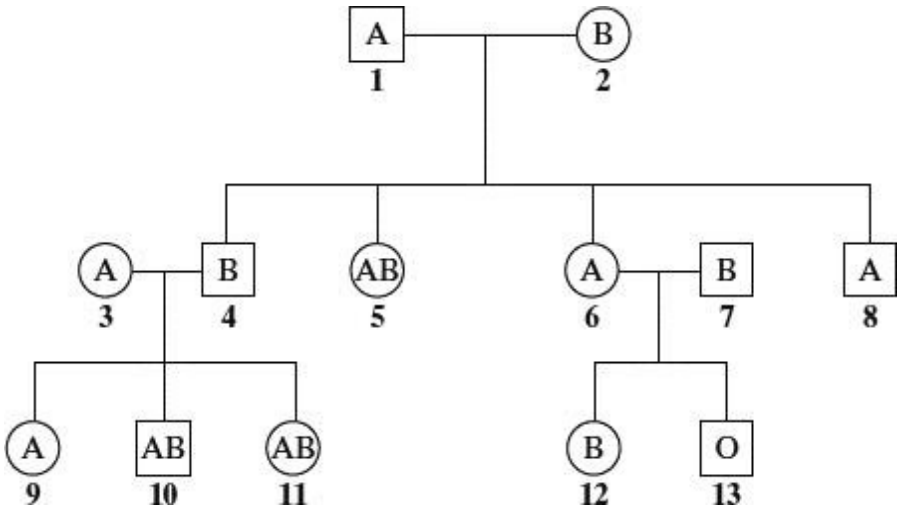
I^A – determines the production of antigen A

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.

_____

_____

(1)

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

_____

(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.

_____

_____

_____

_____

_____

_____

(3)

(Total 5 marks)

Q27.

(a) The control of water balance in the body involves negative feedback.

(i) Describe what is meant by *negative feedback*.

_____

_____

_____

(1)

(ii) Water is removed from the body via the kidneys. Give **two** other ways in which water is removed from the body.

1. _____

2. _____

(2)

(iii) Name the part of the brain which acts as the coordinator in the control of water balance.

_____

(1)

(b) **Figure 1** shows the cells lining the collecting duct in a human kidney. ADH molecules bind to the receptor proteins and this triggers the vesicles containing aquaporins to bind with the plasma membrane next to the lumen. **Figure 2** shows an aquaporin which is a large channel protein.

Figure 1

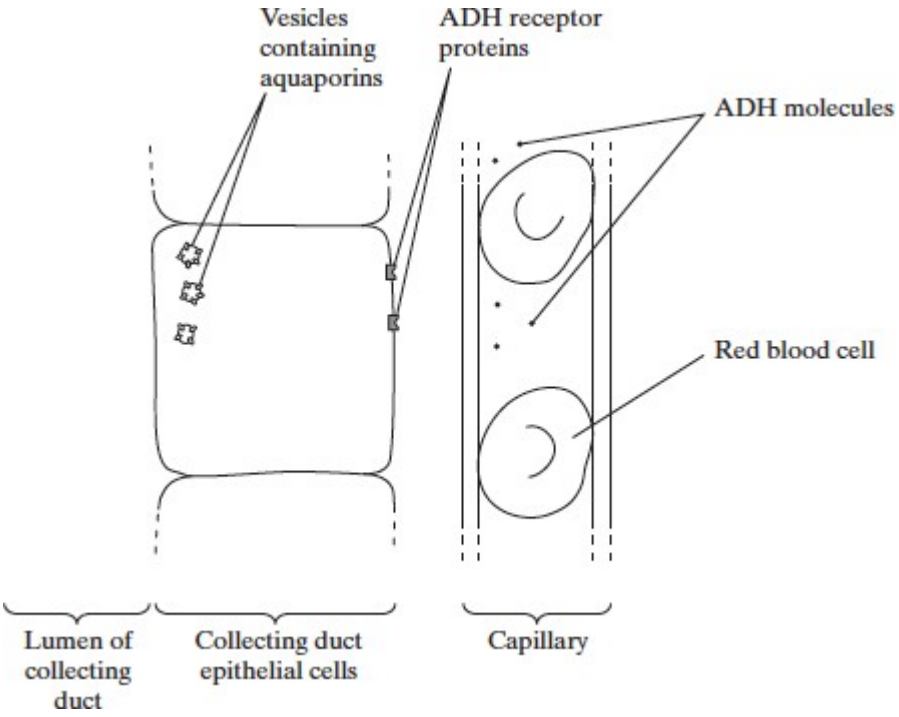
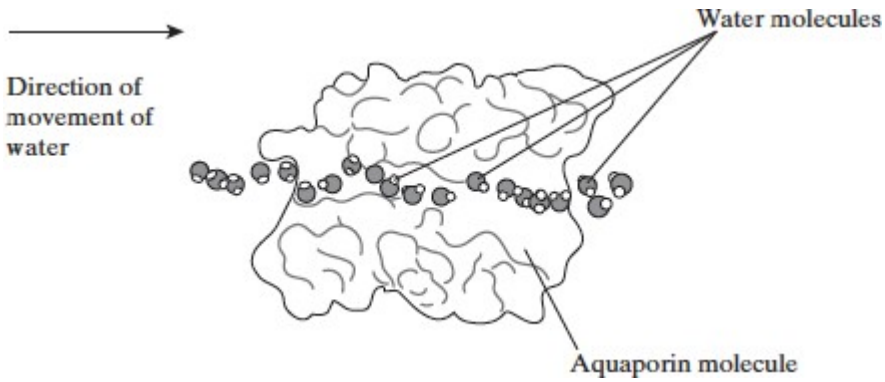


Figure 2



(i) From which gland is ADH released?

_____

(1)

(ii) Use the information given to explain how ADH increases the movement of water from the lumen of the collecting duct into the blood.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(c) The gene for the ADH receptor proteins is found on the X chromosome. One allele of this gene causes a non-functioning receptor protein to be made. This allele is recessive and is one cause of the condition called diabetes insipidus.

(i) What would be the most obvious symptom of diabetes insipidus?

_____

(1)

(ii) Suggest why diabetes insipidus is more common in males.

_____

_____

_____

_____

(2)

(iii) A recessive allele which has harmful effects is able to reach a higher frequency in a population than a harmful dominant allele. Explain how.

_____

_____

_____

_____

_____

_____

(3)

(Total 15 marks)

Q28.

In fruit flies, the allele for grey body, **G**, is dominant to the allele for ebony body, **g**, and the allele for normal wings, **N**, is dominant to the allele for vestigial wings, **n**. Vestigial-winged flies, heterozygous for grey body colour, were crossed with ebony-bodied flies, heterozygous for normal wings.

Complete the genetic diagram to show the genotypes and phenotypes in this cross.

Parental phenotypes Grey body, vestigial wings Ebony body, normal wings

Parental genotypes _____ _____

Gamete genotypes _____ _____

Offspring genotypes

_____

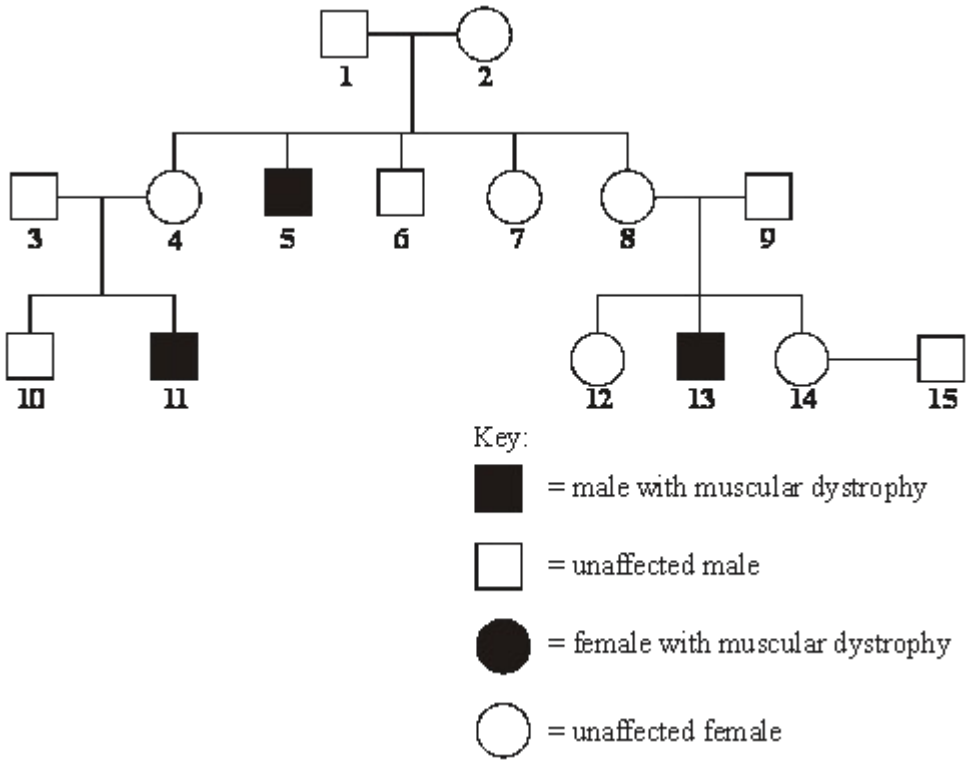
Offspring phenotypes

_____

(Total 4 marks)

Q29.

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?

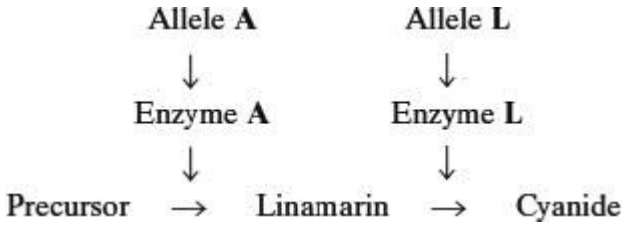
_____

(1)

(Total 5 marks)

Q30.

Cyanide is a poisonous substance. Cyanogenic clover plants produce cyanide when their tissues are damaged. The ability to produce cyanide is controlled by genes at loci on two different chromosomes. The dominant allele, **A**, of one gene controls the production of an enzyme which converts a precursor to linamarin. The dominant allele, **L**, of the second gene controls the production of an enzyme which converts linamarin to cyanide. This is summarised in the diagram.



(a) Acyanogenic clover plants cannot produce cyanide. Explain why a plant with the genotype **aaLl** cannot produce cyanide.

_____

_____

(1)

(b) A clover plant has the genotype **AaLl**.

(i) Give the genotypes of the male gametes which this plant can produce.

_____

(1)

(ii) Explain how meiosis results in this plant producing gametes with these genotypes.

_____

_____

_____

_____

(2)

(c) Two plants, heterozygous for both of these pairs of alleles, were crossed. What proportion of the plants produced from this cross would you expect to be acyanogenic but able to produce linamarin? Use a genetic diagram to explain your answer.

(3)

In an investigation, cyanogenic and acyanogenic plants were grown together in pots. Slugs were placed in each pot and records were kept of the number of leaves damaged by the feeding of the slugs over a period of 7 days. The results are shown in **Table 1**.

Table 1

	Undamaged	**Damaged**
Cyanogenic plants	160	120
Acyanogenic plants	88	192

(d) A x^2 test was carried out on the results.

(i) Suggest the null hypothesis that was tested.

_____

_____

(1)

(ii) x^2 was calculated. When this value was looked up in a table, it was found to correspond to a probability of less than 0.05. What conclusion can you draw from this?

_____

_____

_____

_____

_____

_____

(3)

A second investigation was carried out in a field of grass which had been undisturbed for many years. **Table 2** shows the population density of slugs and the numbers of cyanogenic and acyanogenic clover plants at various places in the field.

Table 2

Population density of slugs	Number of acyanogenic clover plants per m^2	Number of cyanogenic clover plants per m^2
Very low	26	10
Low	17	26
High	0	10
Very high	0	5

(e) Explain the proportions of the two types of clover plant in different parts of the field.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 15 marks)

Q31.

The inheritance of body colour in fruit flies was investigated. Two fruit flies with grey bodies were crossed. Of the offspring, 152 had grey bodies and 48 had black bodies.

(a) Using suitable symbols, give the genotypes of the parents. Explain your answer.

Genotypes _____

Explanation _____

_____

_____

_____

(2)

(b) Explain why a statistical test should be applied to the data obtained in this investigation.

_____

_____

_____

_____

(2)

(c) A species of insect, only found on a remote island, has a characteristic controlled by a pair of codominant alleles, $\mathbf{C^M}$ and $\mathbf{C^N}$.

(i) What is meant by *codominant*?

_____

_____

(1)

(ii) There were 500 insects in the total population. In this population, 300 insects had the genotype $\mathbf{C^M\ C^M}$, 150 had the genotype $\mathbf{C^M\ CN}$ and 50 had the genotype $\mathbf{C^N\ C^N}$. Calculate the actual frequency of the allele $\mathbf{C^N}$ by using these figures. Show your working.

Answer _____

(2)

(iii) Use your answer to (ii) and the Hardy-Weinberg equation to calculate the number of insects that would be **expected** to have the genotype $\mathbf{C^N\ C^N}$.

Answer _____

(3)

(Total 10 marks)

Q32.

Most tigers have fur that is orange with black stripes. The orange colour is controlled by a single gene. The dominant allele, **T**, leads to the production of orange fur and the recessive allele **t** leads to the production of white fur. The black stripes are controlled by a different gene. The dominant allele of this gene, **A** , leads to the production of stripes and the recessive allele, **a**, leads to the production of unstriped fur. A tiger with white fur and no stripes is called a snowy tiger.

(a) What is meant by a *recessive* allele?

_____

_____

(1)

(b) A tiger with orange, striped fur was heterozygous for the gene for coat colour and for the gene for stripes. It was mated with a snowy tiger. Complete the genetic diagram.

Orange, striped tiger × Snowy tiger

Parental genotypes

Genotypes of gametes

Genotypes of offspring

Phenotypes of offspring

(4)

(c) Snowy tigers inhabit the same grasslands as orange, striped tigers. These grasslands are dominated by very tall grass plants. Snowy tigers are less successful hunters. Suggest why.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q33.

One form of baldness in humans is controlled by two alleles, **B** and **b**, of a single gene. This gene is not on the X chromosome but the expression of the gene is affected by the sex of a person.

Men who are **BB** or **Bb** will become bald. Men who are **bb** will not become bald.
Women who are **BB** will become bald. Women who are **Bb** or **bb** will not become bald.

One type of colour blindness is controlled by a sex-linked gene, found on the X chromosome. The dominant allele $\mathbf{X^A}$ leads to normal colour vision and the recessive allele $\mathbf{X^a}$ leads to colour blindness.

(a) (i) Give all the possible genotypes of a bald man who has normal colour vision.

_____

(1)

(ii) Give all the possible genotypes of a woman who will not become bald and who carries one allele for colour blindness.

_____

(1)

(b) A mother and a father are both heterozygous for the gene for baldness. The father has normal colour vision and the mother is heterozygous for the gene for colour blindness. Complete the genetic diagram to show the probability of a son of this couple being colour blind but not becoming bald.

Father Mother

Genotypes of parents

Gametes

Genotypes of sons

Probability of son being colour blind but not becoming bald _____

(4)

(Total 6 marks)

Q34.

Chickens have a structure called a comb on their heads. The drawings show two types of comb.



Pea comb Single comb

The shape of the comb is controlled by two alleles of one gene. The allele for pea comb, **A**, is dominant to the allele for single comb, **a**.

The colour of chicken eggs is controlled by two alleles of a different gene. The allele for blue eggs, **B**, is dominant to the allele for white eggs, **b**.

The genes for comb shape and egg colour are situated on the same chromosome.

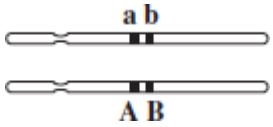
A farmer crossed a male chicken with the genotype **AaBb** with a female chicken that had a single comb and produced white eggs.

(a) What was the genotype of the female parent?

_____

(1)

The diagram shows how the alleles of the genes were arranged on the chromosomes of the male parent.



(b) Which **two** genotypes will be most frequent in the offspring?

_____

(1)

(c) The farmer could identify which of the female offspring from this cross would eventually produce blue eggs. Explain how.

_____

_____

_____

_____

(2)

(d) Genes **A** and **B** are close together on the chromosome. This is important when trying to identify which of the female offspring would produce blue eggs. Explain why.

_____

_____

_____

_____

(2)

(e) Suggest **two** environmental factors which are likely to affect egg production.

1. _____

2. _____

(2)

In chickens it is the males which are XX and the females which are XY.

(f) A gene on the X chromosome controls the rate of feather production. The allele for slow feather production, **F**, is dominant to the allele for rapid feather production, **f**.

A farmer made a cross between two chickens with known genotypes. He chose these chickens so that he could tell the sex of the offspring soon after they hatched by looking at their feathers.

Which of the crosses shown in the table did he make? Explain your answer.

Cross	Genotype of male parent	Genotype of female parent
A	$X^F X^F$	$X^f Y$

B	$X^F X^f$	X^fY
C	$X^f X^f$	X^FY
D	$X^F X^f$	X^FY

Answer _____

Explanation _____

_____

_____

_____

(3)

(g) Female chickens are more likely than male chickens to show recessive sex-linked characteristics. Explain why.

_____

_____

_____

_____

_____

_____

(3)

(Total 14 marks)

Q35.

Hair type in dachshund dogs is controlled by two genes which are on different chromosomes.

Dogs with the **H** allele have wiry hair and dogs with the genotype **hh** have non-wiry hair.

The length of wiry hair is always the same. Dogs with non-wiry hair have either long or short hair. The length of non-wiry hair is controlled by another gene. Dogs with the **D** allele have short hair and those with the genotype **dd** have long hair.

(a) Give all the possible genotypes for dachshunds with non-wiry, short hair.

_____

(1)

(b) What type of interaction is occurring between the two genes? Explain your answer.

_____

_____

_____

_____

(2)

(c) A wiry-haired male with the genotype **HhDd** was mated with a non-wiry, long-haired female with the genotype **hhdd**. Complete the genetic diagram to show the ratio of offspring phenotypes expected in this cross.

Parental phenotypes	Wiry-haired male	Non-wiry, long-haired female
Parental genotypes	**HhDd**	**hhdd**
Gametes		
Offspring genotypes		
Offspring phenotypes		
Ratio of offspring phenotypes		

(3)

(Total 6 marks)

Q36.

(a) Explain **one** way in which the behaviour of chromosomes during meiosis produces genetic variation in gametes.

_____

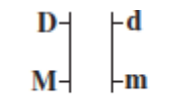
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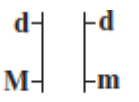
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(2)

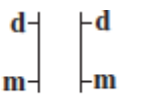
(b) In mosquitoes, the sex of an individual is determined by one gene. Males have the genotype **Mm** and females **mm**.
Another gene is carried on the same chromosome. Normal males and females are homozygous **dd** for this gene. Abnormal males have a dominant **D** allele.
The possible genotypes are shown below. The vertical lines represent homologous chromosomes.



Abnormal male



Normal male



Normal female

During meiosis, allele **D** causes the homologous chromosome carrying the **m** allele to disintegrate. Cells lacking this chromosome do not develop further.

Complete the genetic diagram to show how allele **D** is transmitted from an abnormal male to his offspring.

Parental phenotypes	Abnormal male	Normal female

Parental genotypes 

Gametes _____ _____

Offspring genotype(s) _____

Offspring phenotype(s) _____

(3)

(Total 5 marks)

Q37.

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 $\mathbf{C}^{\mathbf{R}}$ (red) and $\mathbf{C}^{\mathbf{W}}$ (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.

_____

_____

(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.

_____

_____

_____

_____

(2)

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

_____

_____

(1)

(Total 9 marks)

Q38.

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

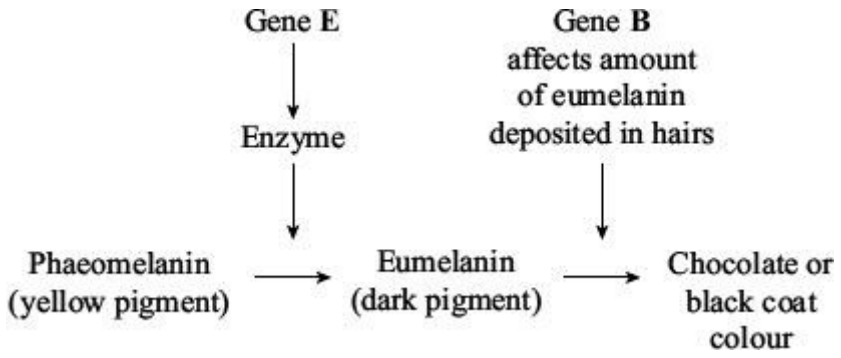
Offspring genotypes

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;

_____

_____

_____

_____

(2)

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

_____

_____

_____

_____

(2)

(Total 9 marks)

Q39.

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.

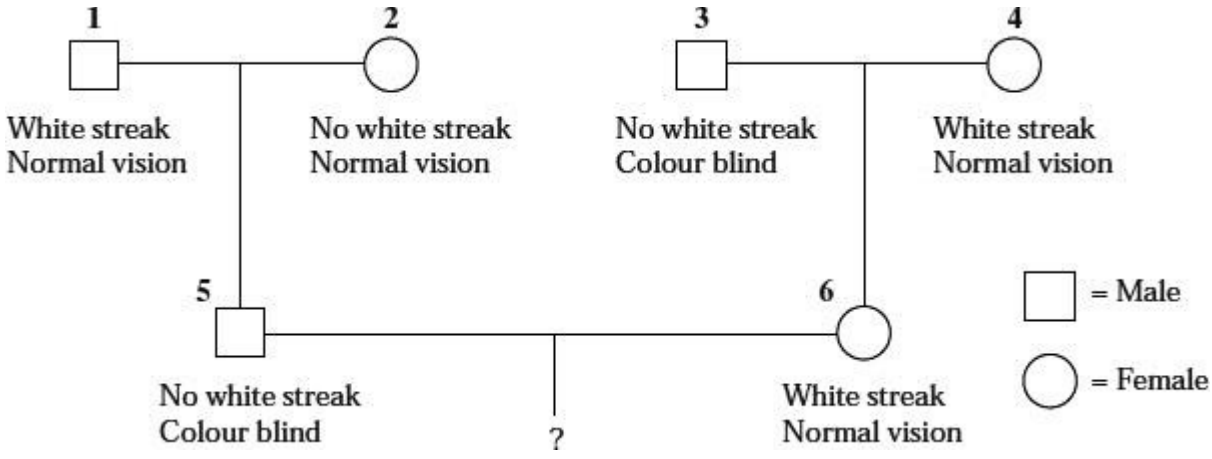
_____

_____

_____

(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**

_____

Individual **6**

_____

(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)

Q40.

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?

_____

_____

_____

_____

(2)

(b) The table shows some genotypes and phenotypes.

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

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

_____

_____

(1)

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

_____

_____

(2)

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

_____

_____

_____

_____

(2)

(c) Using the information given, explain why the phenotypes of rabbits with **AABB** and **AA^{h}BB** genotypes are the same.

_____

_____

_____

_____

(2)

(Total 9 marks)

Q41.

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.

_____

_____

_____

_____

(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.

_____

_____

_____

_____

_____

_____

(3)

(Total 5 marks)

Q42.

Coat colour in mice is controlled by two genes, each with two alleles. The genes are on different chromosomes.

One gene controls the pigment colour. The presence of allele **A** results in a yellow and black banding pattern on individual hairs, producing an overall grey appearance called agouti. Mice with the genotype aa do not make the yellow pigment and are, therefore, black.

The other gene determines whether any pigment is produced. The allele **D** is required for development of coat colour. Mice with the genotype **dd** produce no pigment and are called albino.

(a) What type of gene interaction is occurring between the two genes? Explain your answer.

_____

_____

_____

_____

(2)

(b) Give all the possible genotypes for a black mouse.

_____

(1)

(c) An agouti mouse of unknown genotype was crossed with an albino mouse of unknown genotype. Their offspring included albino, agouti and black mice.

(i) What was the genotype of the agouti parent?

_____

(1)

(ii) Give **two** possible genotypes for the albino parent.

_____

(1)

(iii) Suggest how the actual genotype of the albino parent could be determined.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q43.

(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 _____

_____

_____

(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.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q44.

Figure 1 and **Figure 2** show the chromosomes from a single cell at different stages of meiosis.

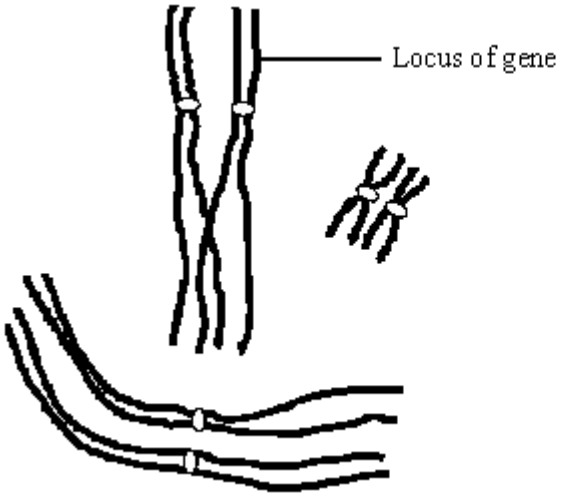


Figure 1

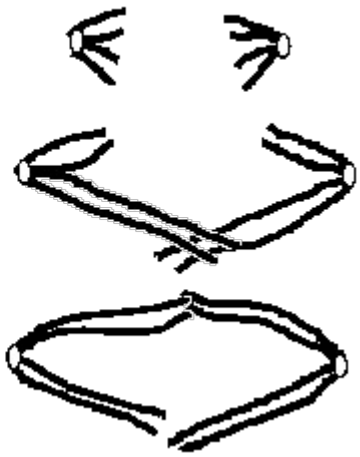


Figure 2

(a) What is the diploid number of chromosomes in the organism from which this cell was taken?

_____

(1)

(b) Describe what is happening to the chromosomes at the stage shown in

(i) **Figure 1**;

_____

_____

_____

_____

(2)

(ii) **Figure 2**.

_____

_____

_____

_____

(2)

(c) (i) The genotype of this organism is **Bb**. The locus of this pair of alleles is shown in **Figure 1**.

Label **two** chromosomes on **Figure 2** to show the location of the **B** allele and the location of the **b** allele.

(1)

(ii) How many genetically different gametes can be produced by meiosis from a cell with the genotype, **Bb Cc Dd**? Assume these genes are located on

different pairs of homologous chromosomes. Show your working.

_____

(2)

(Total 8 marks)

Q45.

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?

_____

_____

(1)

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

(i) Give the phenotype of the male.

_____

(1)

(ii) Give the genotype of the tortoiseshell female.

_____

(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**.

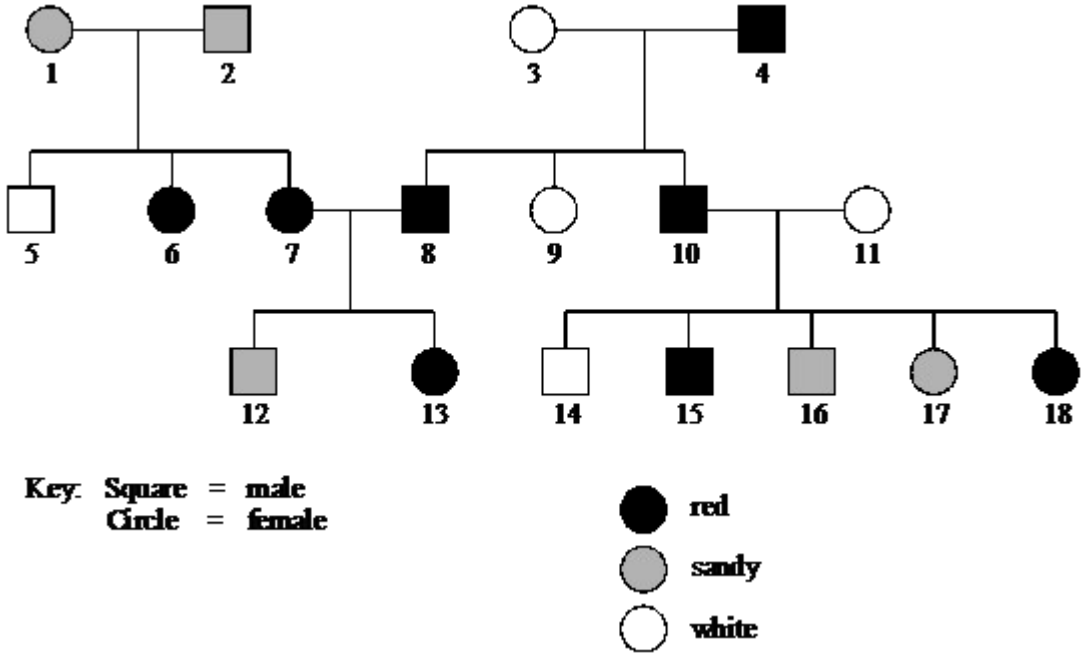
A cream-coloured male cat mated with a black female whose genotype was $\mathbf{X^gX^g}$ **Dd**. Male kittens of two different colours were produced. Complete the genetic diagram.

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)

Q46.

The diagram shows the inheritance of coat colour in pigs through three generations.



(a) Explain **one** piece of evidence from the diagram which shows that coat colour is **not** controlled by one gene with two codominant alleles.

_____

_____

_____

_____

_____

_____

_____

(3)

Two hypotheses were put forward to explain the results, each based on the action of two pairs of alleles.

	Hypothesis 1	**Hypothesis 2**
Phenotype	**Genotype**	**Genotype**
Red	**A_B_**	**A_B_** or **A_bb**
Sandy	**A_bb** or **aaB**	**aaB_**
White	**aabb**	**aabb**

(_ represents either a dominant or a recessive allele of the gene)

(b) Assuming that Hypothesis 1 is correct, give **one** possible genotype for each of the following individuals in the diagram.

11 _____

10 _____

2 _____

(2)

(c) Explain **one** piece of evidence from the diagram which shows that Hypothesis 2 should be rejected.

_____

_____

_____

_____

(2)

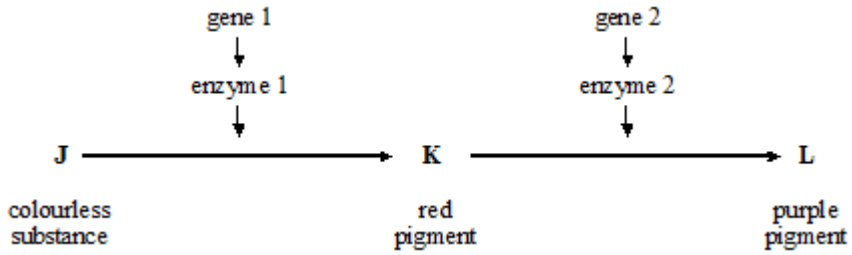
(d) Individual 18 was crossed with a pig of genotype **Aabb**.
Use Hypothesis 1 to predict the genotypes and the ratio of phenotypes expected in the
offspring of this cross.

	Individual 18	Other parent
Parental genotypes	_____	**Aabb**
Parental gametes		
Offspring genotypes		
Offspring phenotypes		
Expected ratio of offspring phenotypes		

(4)
(Total 11 marks)

Q47.

A species of flowering plant can have white, red or purple flowers. The colour of the flowers is controlled by two genes. Each gene is found on a different chromosome, and is responsible for one step in a biosynthetic pathway. The biosynthetic pathway is



Gene 1 has the dominant allele **A** and the recessive allele **a**. Gene 2 has the dominant allele **B** and the recessive allele **b**. In both cases, the dominant allele needs to be present for the production of the associated enzyme.

(a) Explain how the two genes are involved in producing white, red or purple flowers.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(b) (i) A homozygous red-flowered plant was crossed with a homozygous white-flowered plant. All the flowers of the offspring were purple. What was the genotype of

the red-flowered parent;

_____

the white-flowered parent?

_____

(2)

(ii) The purple-flowered offspring were crossed. What phenotypic ratio would you expect in the next generation? Use a genetic diagram to explain your answer.

(4)

(c) (i) Genetically, there are different types of white-flowered plants of this species. Give their different genotypes.

_____

(1)

(ii) You have samples of fresh petals from the two homozygous types of white flowers, and a pure sample of the red pigment, **K**. Explain, in outline, how you might distinguish the two types of petal from each other.

_____

_____

_____

_____

_____

(2)

(Total 15 marks)