Inheritance Pack 1

These practice questions can be used by students and teachers and is

Suitable for AQA A Level 7402 Biology Topic Question

Level: AQA A LEVEL 7402

Subject: Biology

Exam Board: AQA A Level 7402

Topic: Inheritance Pack 1

1

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(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.

_____

_____

(Extra space) _____

(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 resultswere significantly different from the expected results?

Give the reason for your choice of statistical test.

(2)

(Total 8 marks)

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

2

_____

_____

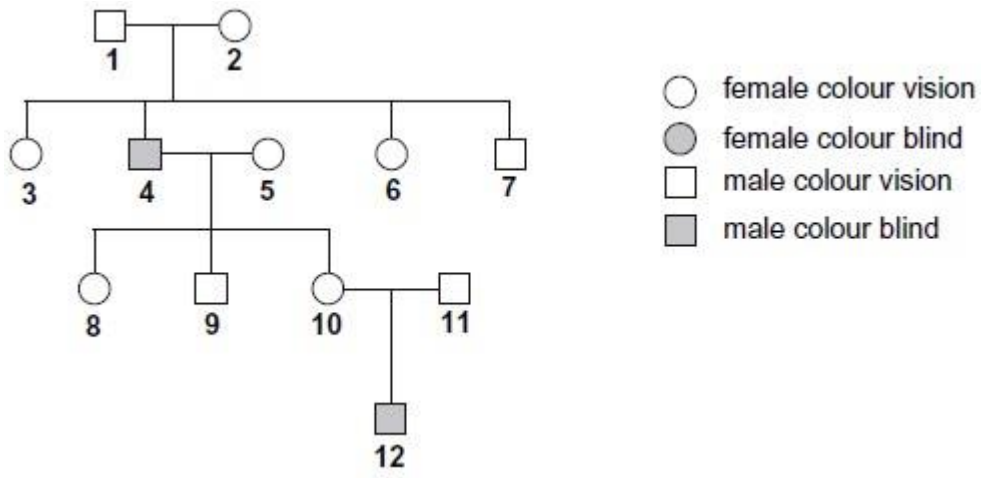
_____

_____

(2)

(b) One type of colour blindness is controlled by a gene carried on the X chromosome. Theallele 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)

Read the following passage carefully.

3

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.

(Extra space) _____

(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** _____

(Extra space) _____

(4)

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

(Extra space)

(3)

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

(Extra space)

(3)

(e) A small amount of DNA can be extracted from mitochondria and DNA sequencing used totry 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)

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

_____

_____

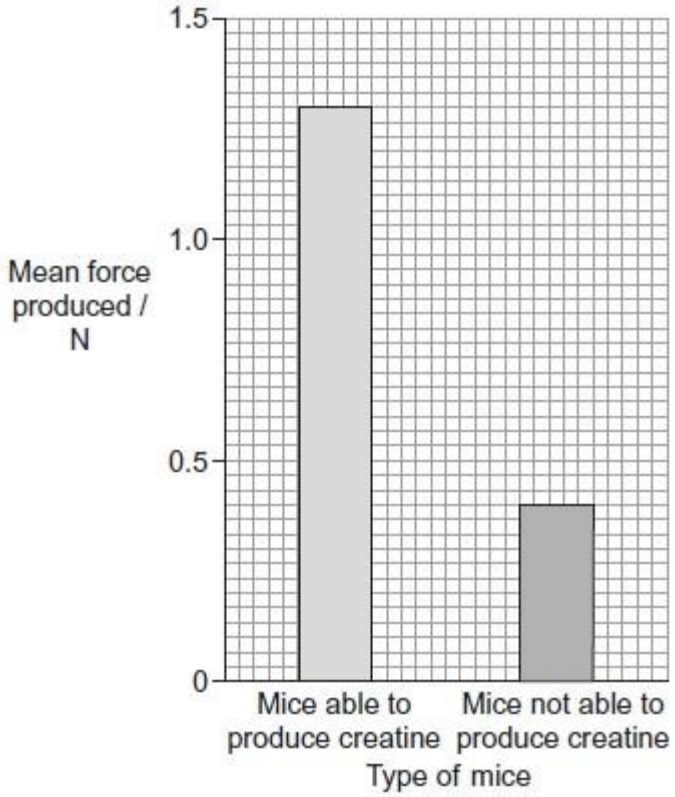
_____

_____

(2)

(b) Scientists investigated the effect of not being able to produce creatine on the forceproduced 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 toproduce 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)

5 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 DNAfragments.

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

(2)

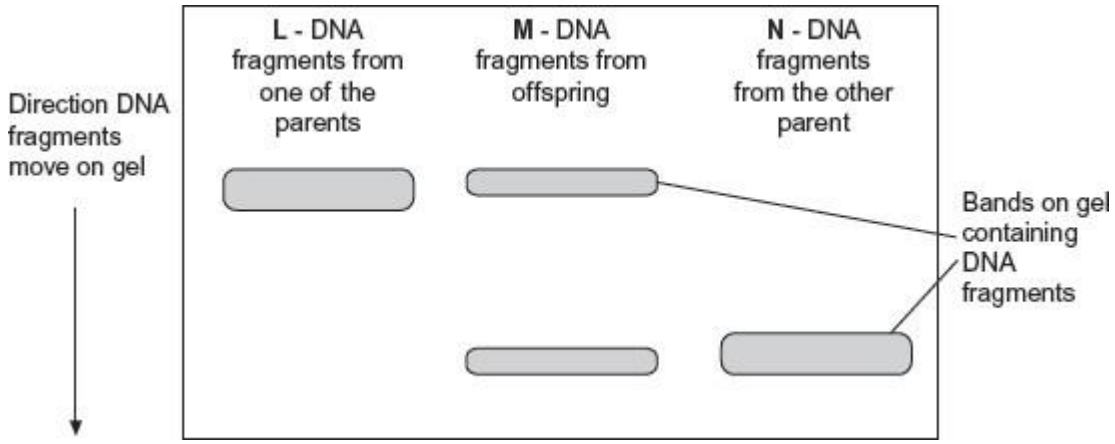
The scientists added two different primers to each sample of DNA fragments for the polymerase chain reaction (PCR).

- 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**.

[Extra space] _____

_____

_____

(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 toincreased activity of an enzyme called P450 monooxygenase (PM). This enzyme breaks down insecticides.

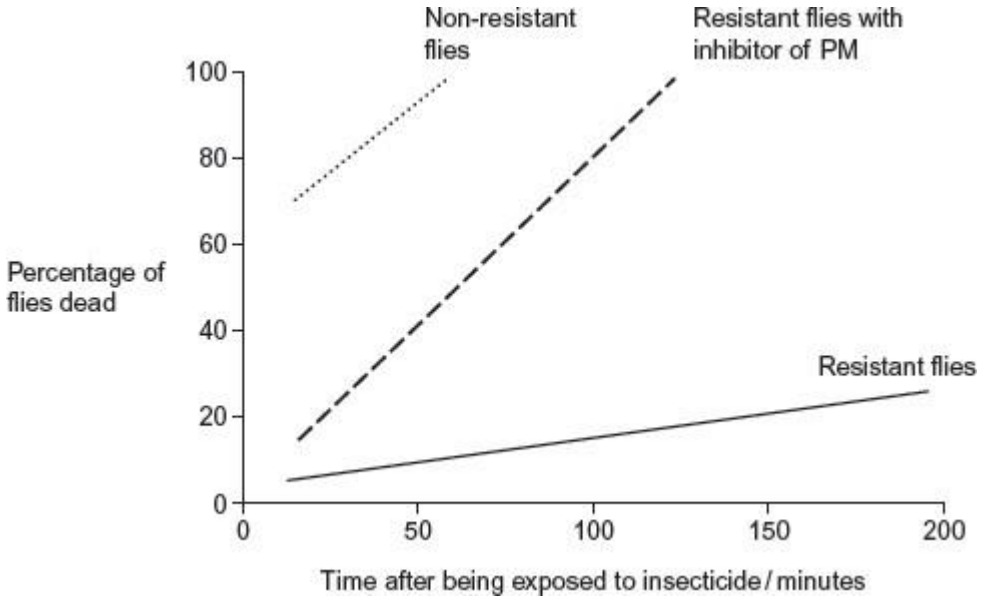
The scientists obtained large numbers of resistant and non-resistant flies. They then set up the following experiments.

- 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-resistantflies.

_____

_____

_____

_____

_____

(2)

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

Explain how these data support this conclusion.

_____

_____

_____

_____

_____

[Extra space] _____

(4)

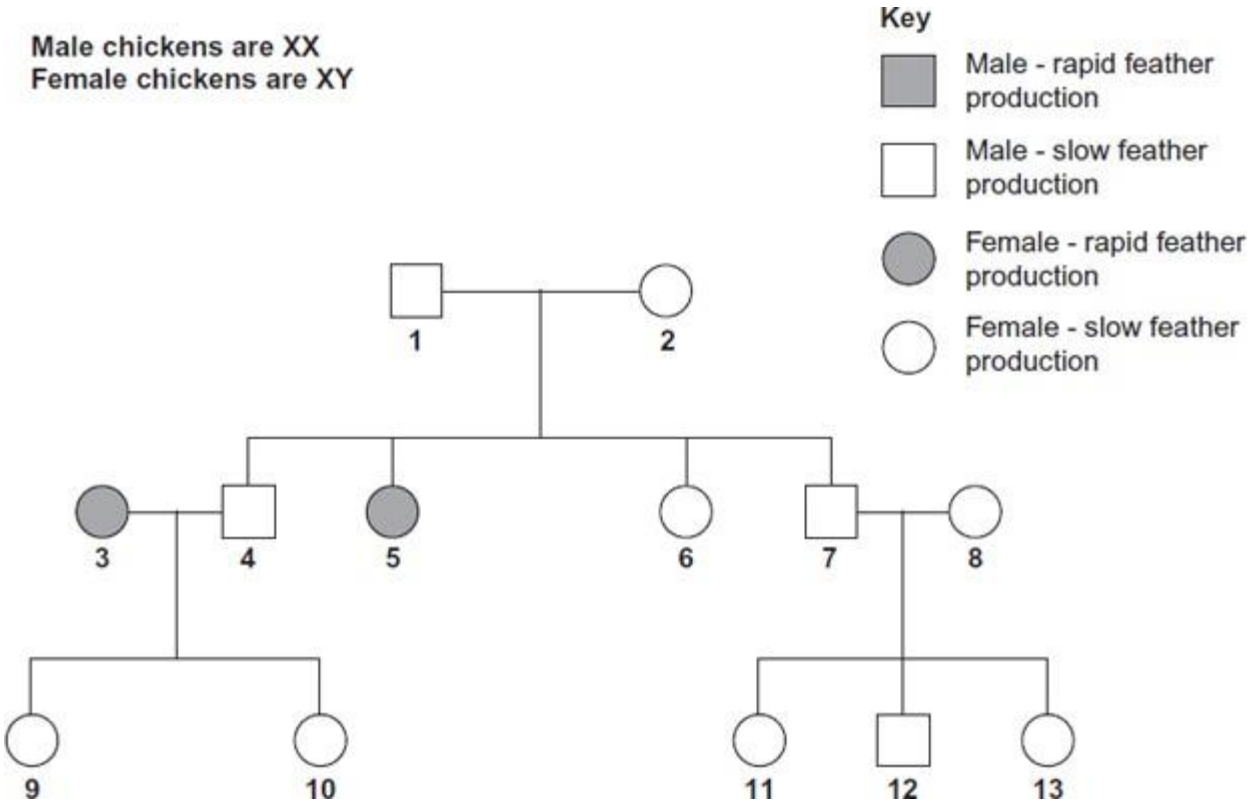
(Total 15 marks)

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

(a) Use this information to explain why recessive, sex-linked characteristics are more commonin 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 withrapid 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 whichare **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)

7 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 allthe 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 forpolydactyly is dominant.

(i) In a population, 19% of cats had extra toes. Use the Hardy-Weinberg equation tocalculate 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 thefrequencies of the homozygous genotypes for this gene in their breeding populations over time.

_____

_____

_____

_____

(1)

(Total 8 marks)

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

_____

_____

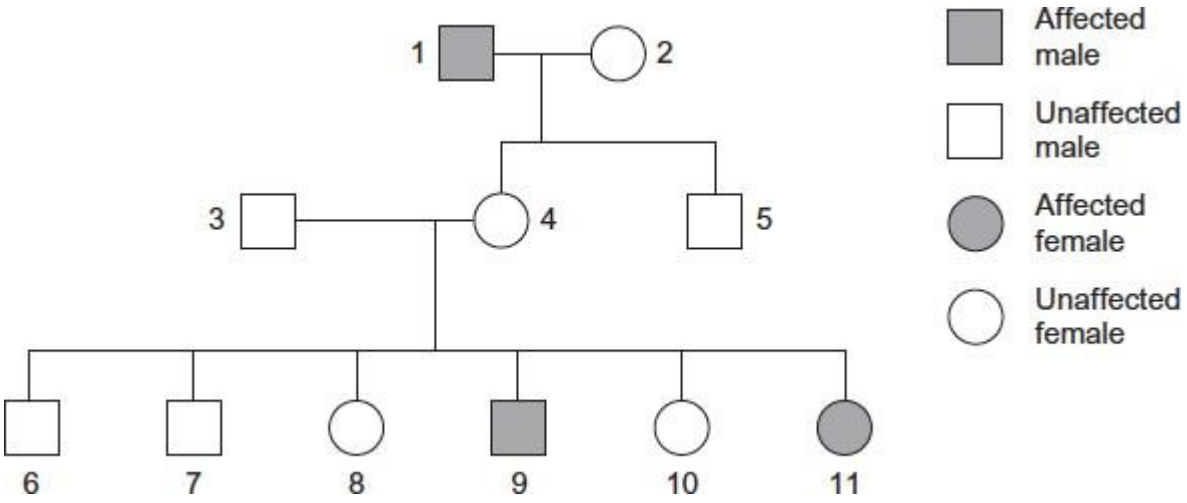
_____

_____

_____

(2)

(b) Tay-Sachs disease is a human inherited disorder. Sufferers of this disease often die duringchildhood. 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.

_____

_____

_____

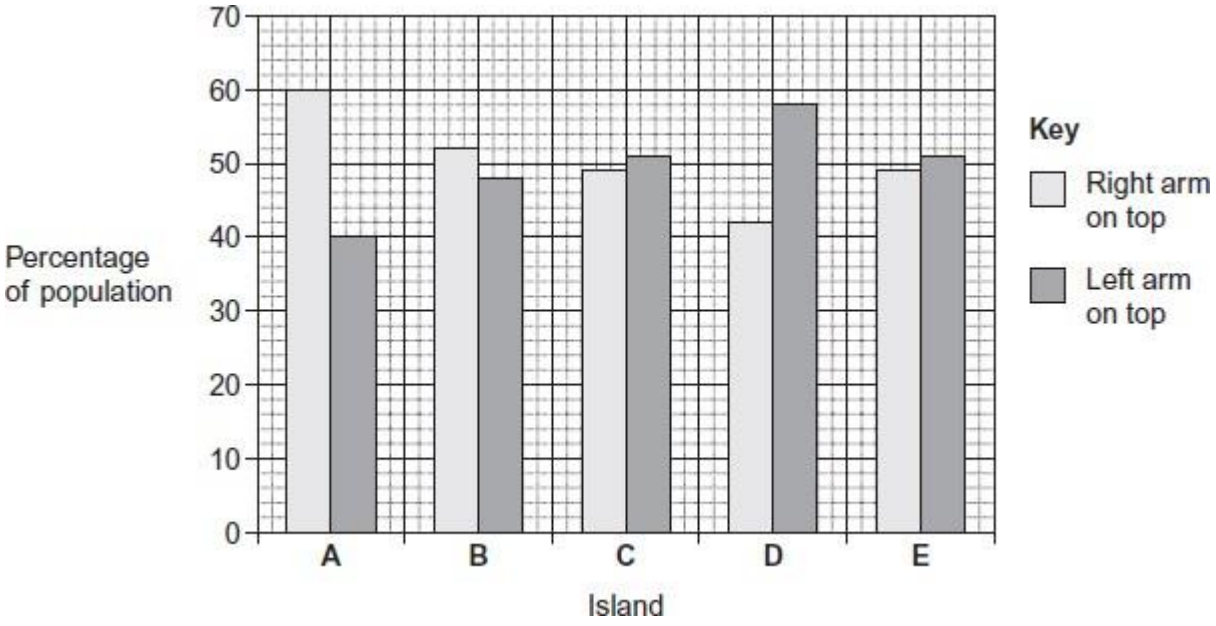
(1)

(Total 10 marks)

9 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.

(Extra space)

(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)

10 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 UKare right-handed.
Do you agree with this conclusion? Give reasons for your answer.

_____

_____

_____

_____

_____

(2)

(Total 5 marks)

11 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, agene 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 arecessive allele carried on the X chromosome. Explain why.

_____

_____

_____

_____

_____

(2)

(Total 8 marks)

12 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-shelledsnails. 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 iscontrolled 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.

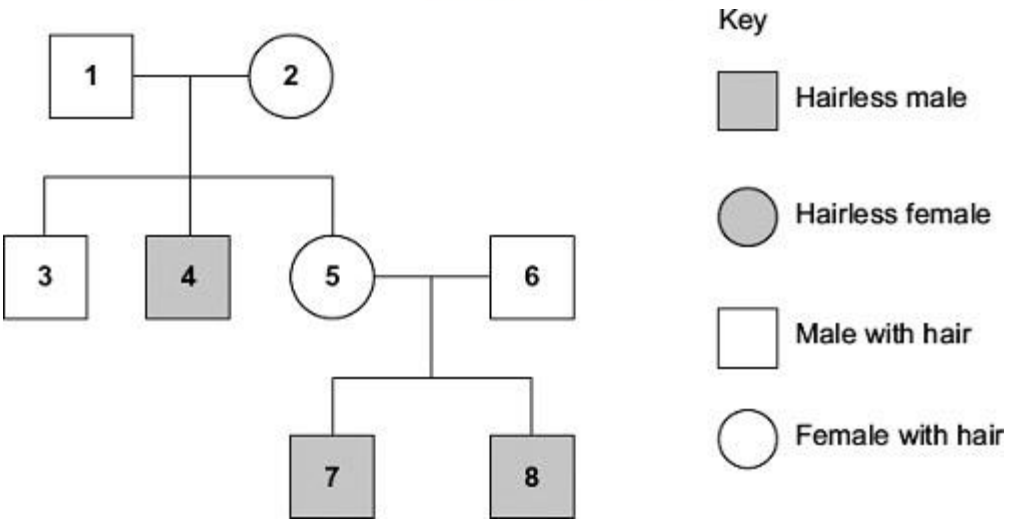
Answer _____ %

(3)

(Total 8 marks)

13 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)

14 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 $\mathbf{b^i}$ 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 genotypesshown.

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 fromthe 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)

15

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

_____

_____

_____

(1)

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

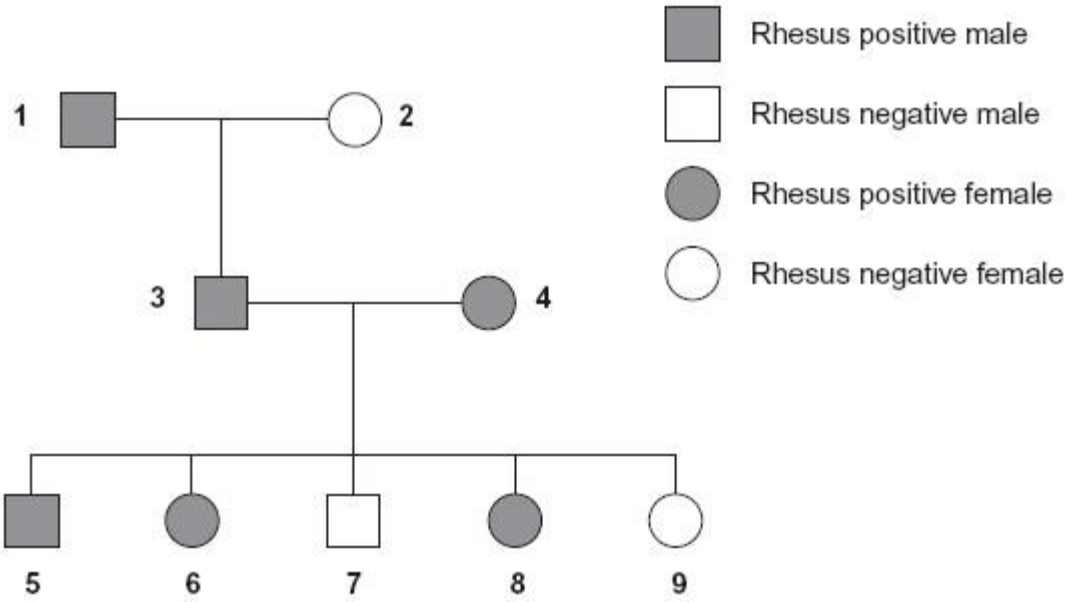
_____

_____

_____

(1)

(b) The Rhesus blood group is genetically controlled. The gene for the Rhesus blood grouphas 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-Weinbergequation to calculate the percentage of this population that you would expect to be heterozygous for the Rhesus gene.

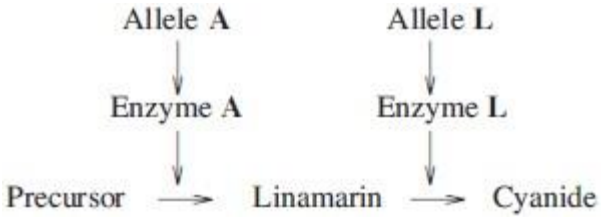
Show your working.

Answer _____

(3)

(Total 9 marks)

16 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 proportionof 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.

(Extra space)

(4)

(Total 15 marks)

17 (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 beproduced.

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)

18 (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 arisenby 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 differentchromosomes. 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 = _____

Parental phenotypes	Male Short, black hair	Female 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 malewhich 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.

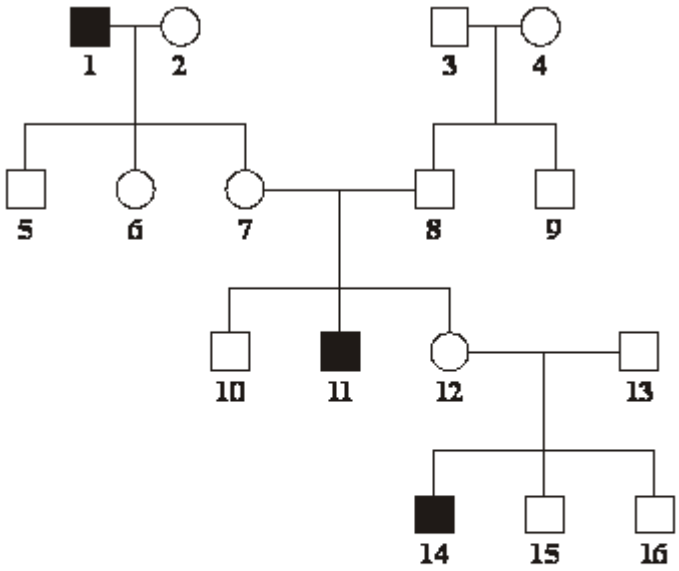
_____

_____

(1)

(Total 10 marks)

19 **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

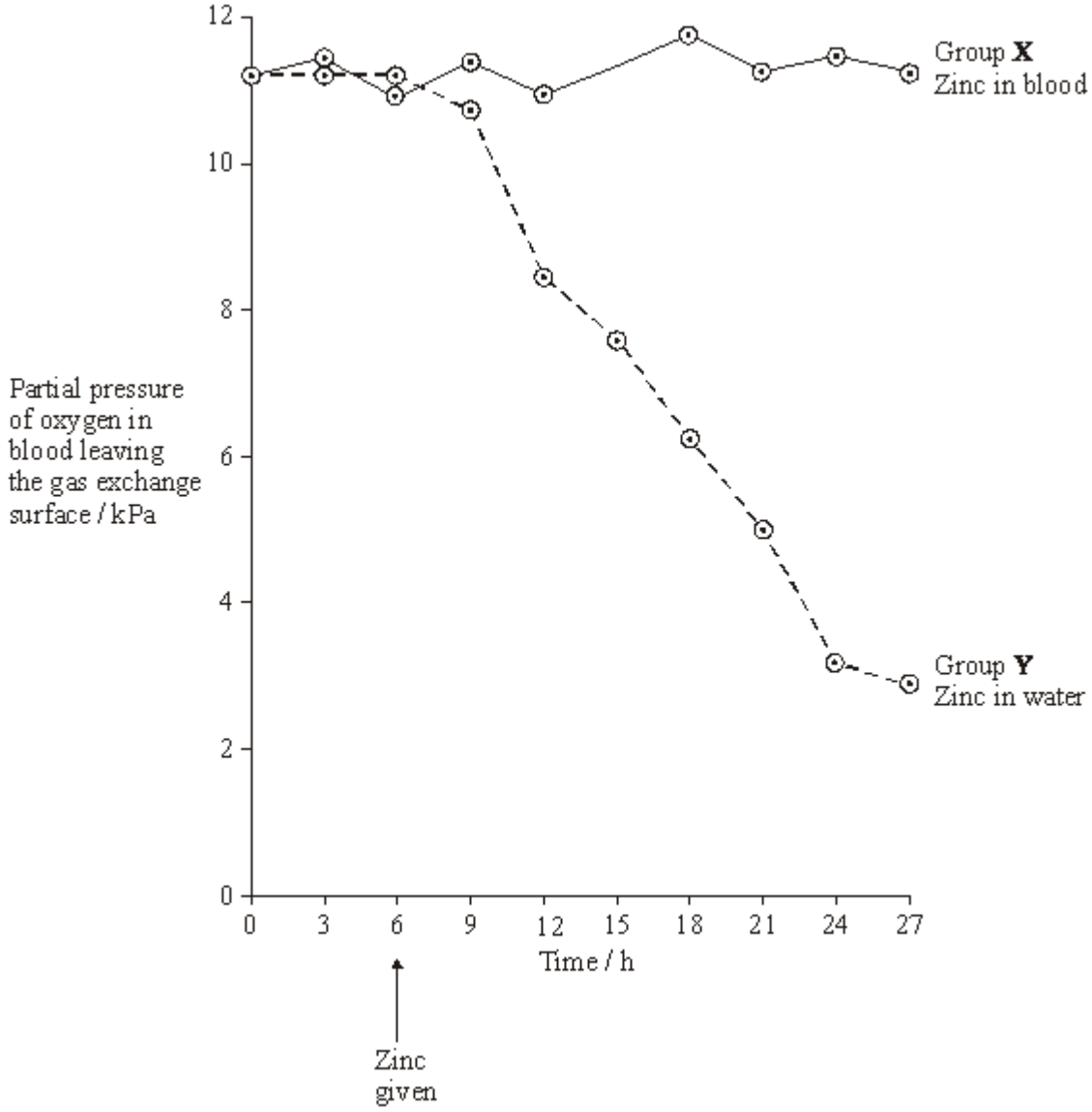
Probability = _____

(Total 4 marks)

20 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. Explainwhy 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 thisinvestigation.

_____

_____

_____

_____

(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 andpasses 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 theconcentration 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? Usesuitable 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 thewoodlice.

_____

_____

(2)

(f) Yorkshire fog is a species of grass. Two varieties of Yorkshire fog were studied. One varietywas 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 andphosphorus-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 highconcentration 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 ofarsenic 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.

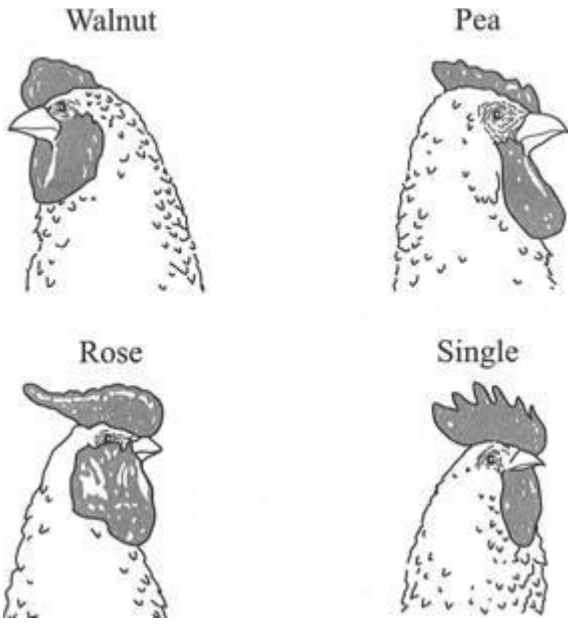
_____

(3)

(Total 20 marks)

21 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-combedfemale, 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 theconditions 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)

22 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:

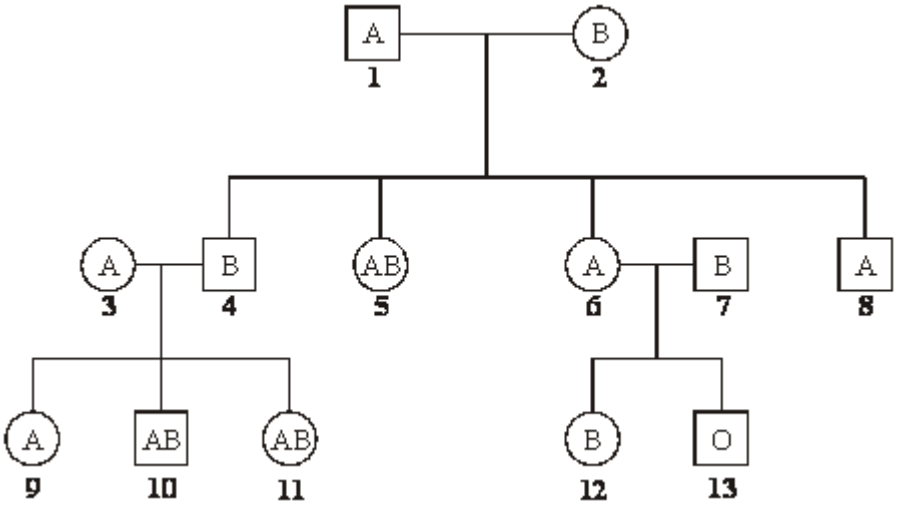
I^A – determines the production of antigen A

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 areason 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)

23 (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 waterbalance.

_____

(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

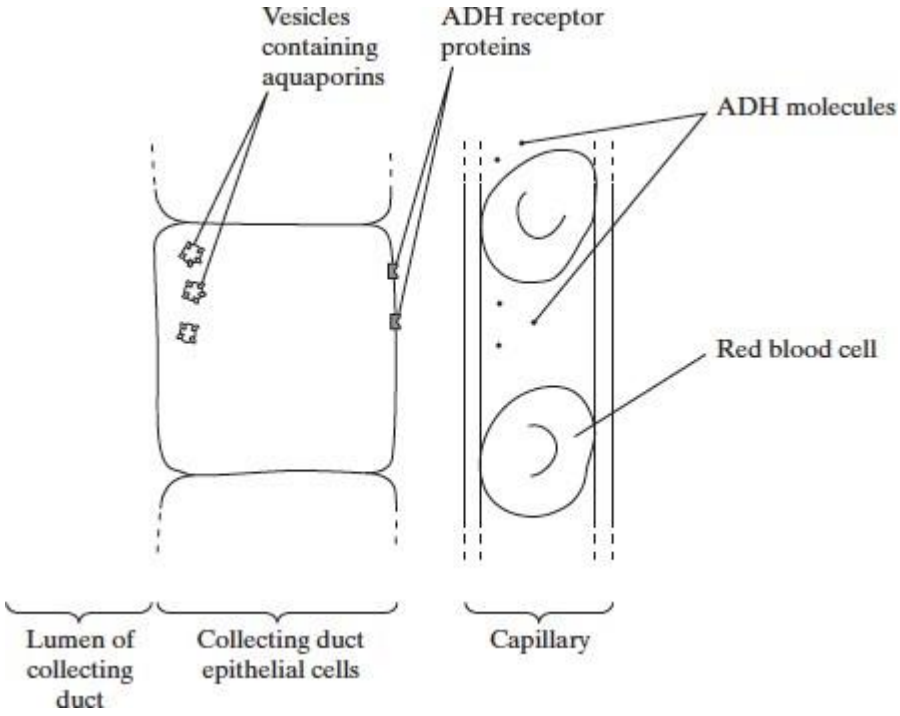
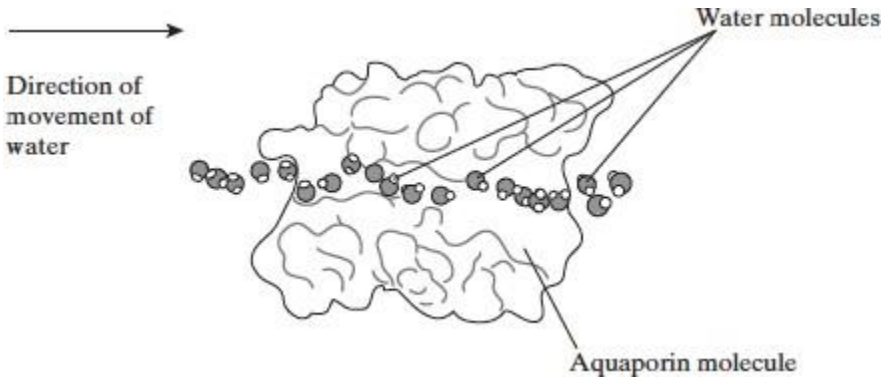


Figure 2



(i) From which gland is ADH released?

_____

(1)

(ii) Use the information given to explain how ADH increases the movement of water fromthe 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 apopulation than a harmful dominant allele. Explain how.

(3)

(Total 15 marks)

Mark schemes

(a) (Genes / loci) on same chromosome.

1 **1**

(b) 1. GN and gn linked;
2. GgNn individual produces mainly GN and gn gametes;
3. Crossing over produces some / few Gn and gN gametes; 4. So few(er) Ggnn and ggNn individuals.

4

(c) (Grey long:grey short:black long:black short) =1:1:1:1

1

(d) 1. Chi squared test;2. Categorical data.

2

[8]

2

(a) 1. (Expression/appearance/characteristic due to) genetic constitution/genotype/allele(s);

Accept: named characteristic.

Accept: homozygous/ heterozygous/genes/DNA.

Ignore: chromosomes.

2. (Expression/appearance/characteristic due to) environment;

2

(b) (i) 1. (Individual) 2 has colour vision but 4 is colour blind / 10 has colour vision but 12 is colour blind
OR
4/12 is colour blind but parents have colour vision;

2. So 2/10 must be heterozygous/carriers;

*Accept: (1), 2 and 4 **or** 10, (11) and 12.*

Accept: any suitable description and explanation equivalent to points 1 and 2.

Reject: (both) parents heterozygous/carriers.

Accept: correct genotypes for 2 and 10.

Accept: for 2 marks, if it was dominant the daughters (8 and 10) of individual 4 would be colour blind.

2

(ii) X^BX^b **or** X^bX^B;

Reject: Bb / bB

Accept: XBXb or XbXB;

Accept: use of other letter than B

e.g. X^RX^r, X^HX^h.

1

(c) (i) 2 marks for the correct answer of 0.0625 / 6.25% / $\frac{1}{16}$;;

1 mark for incorrect answer but shows 0.03125 / 3.125% / $\frac{1}{32}$;

Accept: 0.063 / 0.06 / 6.3% / 6% for 2 marks.

Accept: incorrect answer but shows / 0.0313 / 0.031 / 0.03 / 3.13% / 3.1% / 3% / ¼ × ¼ / 0.25 × 0.25 for 1 mark.

Note: if probability is calculated as a percentage but no % shown in the answer then deduct one mark. For example 6.25 = one mark, 3.125 = zero.

2

(ii) 2 marks for the correct answer of 48(%);;
1 mark for an incorrect answer but shows understanding that 2pq = heterozygous or attempts to calculate 2pq;

1 mark maximum for the answer of 0.48.

2

3

[9] (a) 1. Reduction in ATP production by aerobic respiration;
2. Less force generated because fewer actin and myosin interactions in muscle;
3. Fatigue caused by lactate from anaerobic respiration.

3

(b) Couple **A**,
1. Mutation in mitochondrial DNA / DNA of mitochondrion affected;
2. All children got affected mitochondria from mother;
3. (Probably mutation) during formation of mother's ovary / eggs;

Couple **B**,
4. Mutation in nuclear gene / DNA in nucleus affected;
5. Parents heterozygous;
6. Expect 1 in 4 homozygous affected.

4 max

(c) 1. Change to tRNA leads to wrong amino acid being incorporated into protein;
2. Tertiary structure (of protein) changed;
3. Protein required for oxidative phosphorylation / the Krebs cycle, so less / noATP made.

3

(d) 1. Mitochondria / aerobic respiration not producing much / any ATP;
2. (With MD) increased use of ATP supplied by increase in anaerobic respiration;
3. More lactate produced and leaves muscle by (facilitated) diffusion.

3

(e) 1. Enough DNA using PCR;
2. Compare DNA sequence with 'normal' DNA.

2

[15]

4

(a) 1. (Reaction with ATP) breaks/allows binding of myosin to actin/ actinomyosin bridge;
2. Provides energy to move myosin head;

1. Credit 'breaks' or 'allows' binding to actin (because cyclical)

2. Allow in context of 'power stroke' or 're-cocking' (becausecyclical)

2. Ignore contraction on its own

2

(b) (i) Any value between 68.5 and 69.49 (%);;

If get difference of 0.9 but calculation of percentage incorrect, then award 1 mark;

2

(ii) (Mutant mice)

1. Unable to make phosphocreatine/ less phosphateavailable to make/recycle ATP;
2. So less energy/so less ATP available for contraction/fastmuscle fibres;

1 and 2. Reject production/creation of energy once

2. Accept less energy for grip

2. Accept no energy/no ATP for contraction/fast muscle fibres

2

(c) 1. (Heterozygous) have one dominant/normal allele (for creatine production);

2. (This) leads to production of enough/normal amount of creatine;

1. Accept has one allele/one copy of the gene for/that is making creatine

2

[8]

5 (a) 1. Cut (DNA) at same (base) sequence / (recognition) sequence;

Accept: cut DNA at same place

2. (So) get (fragments with gene) **R** / required gene.

Accept: 'allele' for 'gene' / same gene

2

(b) 1. Each has / they have a specific base sequence;

2. That is complementary (to allele r or R).

Accept description of 'complementary'

2

(c) 1. Fragments L from parent rr, because all longer fragments / 195 base pair fragments;

Ignore: references to fragments that move further / less, require identification of longer / shorter or 195 / 135 Accept: (homozygous) recessive

2. Fragments N from parent RR, because all shorter fragments / 135 base pair fragments;

1 and 2 Accept: A3 for 195 and A4 for 135

2. Accept: (homozygous) dominant

3. (M from) offspring heterozygous / Rr / have both 195 and 135 base pairfragments.

Accept: have both bands / strips

Reject: primer longer / shorter

3

(d) 1. (Cells in mitosis) chromosomes visible;
2. (So) can see which chromosome DNA probe attached to.

2

(e) (i) 1. For comparison with resistant flies / other (two) experiments / groups;

Ignore: compare results / data / no other factors

2. To see death rate (in non-resistant) / to see effect of insecticide in non-resistant / normal flies. *Accept: 'pesticide' as 'insecticide'*

Accept to see that insecticide worked / to see effect of enzyme

2

(ii) (PM must be involved because)
1. Few resistant flies die (without inhibitor);
2. More inhibited flies die than resistant flies;
3. (PM) inhibited flies die faster (than resistant flies);

(Other factors must be involved because)
4. Some resistant flies die;
5. But (with inhibitor) still have greater resistance / die slower thannon-resistant flies.

Accept: (with inhibitor) die slower than non-resistant flies

4 max

[15] (a) (Recessive) allele is always expressed in females / females have one

6

(recessive) allele / males need two recessive alleles / males need to be homozygous recessive / males could have dominant and recessive alleles / be heterozygous / carriers;

Accept: Y chromosome does not carry a dominant allele. Other answers must be in context of allele not chromosome or gene.

1

(b) (i) 1. 1, (2) and 5;

Accept: for 1 mark that 1 and 2 have slow (feather production) but produce one offspring with rapid (feather production).

Neutral: any reference to 3 being offspring of 1.

2. 1 must possess / pass on the recessive <u>allele</u> / 1 must be a carrier / heterozygous / if slow (feather production) is recessive all offspring of (1 and 2) would be slow (feather production) / if rapid (feather production) was dominant 1 would have rapid (feather production);

Reject: both parents must be carriers / possess the recessive allele.

Reject: one of the parents (i.e. not specified) must be a carrier / heterozygous.

2

(ii) 5 = $X^f Y$ / $X^f Y$

-

/

f

/

f

-

/

f

Y

;

7 = X^FX^f **and** X^FX^F (either way round) /

or X^fX^F **and** X^FX^F (either way round) /

or X^FX^f, X^fX^F **and** X^FX^F(in any order);

Note: allow 5 = X^fY, X^fY.

Accept: for both 5 and 7 a different letter than F. However, lower case and capital letter must correspond to that shown in the answer. For example accept 7 = X^RX^r and X^RX^R.

2

(iii) X^FX^f **and** X^fY **or** X^fX^F **and** X^fY **or**

X^FX^f **and** X^fY^- or X^fX^F **and** X^fY^- / **or**

Ff **and** fY / **or** Ff **and** fY^- / **or** Ff

and f- /

or Ff **and** f;

Accept: a different letter than F. However, lower case and capital letter must correspond to that shown in the answer.

Accept: each alternative either way round.

1

(c) Correct answer of 32 (%) = 3 marks;;;

Accept: 0.32 = 2 marks

If incorrect answer, allow following points

1. p^2 / q^2 = 4% / 0.04 / or p / q = 0.2;

2. Shows understanding that 2pq = heterozygotes / carriers;

Accept: answer provided attempts to calculate 2pq. This can be shown mathematically i.e. 2 x two different numbers.

3 **[9]**

7

(a) Both alleles are expressed / shown (in the phenotype).

Accept: both alleles contribute (to the phenotype)

Neutral: both alleles are dominant

1

(b) Only possess one allele / Y chromosome does not carry allele / gene / can't beheterozygous.

Accept: only possess one gene (for condition)

Neutral: only 1 X chromosome (unqualified)

1

(c) 1. X^GX^B, X^BX^B, X^GY, X^BY;

Accept: equivalent genotypes where the Y chromosome is shown as a dash e.g. X^G-, or is omitted e.g. X^G

Reject: GB, BB, GY, BY as this contravenes the rubric

2. Tortoiseshell female, black female, ginger male, black male;

3. (Ratio) 1:1:1:1

2 and 3. Award one mark for following phenotypes tortoiseshell, black, (black) ginger in any order <u>with</u> ratio of 1:2:1 in any order.

Allow one mark for answers in which mark points 1, 2 and 3 are not awarded but show parents with correct genotypes i.e. X^GX^B and X^BY ***or gametes as*** *X^G, X^B and X^B, Y*

3. Neutral: percentages and fractions

3. Accept: equivalent ratios e.g. for 1:1:1:1 allow 0.25 : 0.25 : 0.25 : 0.25

3

(d) (i) Correct answer of 0.9 = 2 marks;

Incorrect answer but shows $q^2 = 0.81$ = one mark.

Note: 0.9% = one mark

2

(ii) Homozygous dominant increases and homozygous recessive decreases.

1

8 **[8]** (a) 1. Expression / appearance / characteristic due to genetic constitution / genotype / allele(s);

1. Accept: named characteristic

1. Accept: homozygous / heterozygous / genes / DNA

1. Neutral: chromosomes

2. (Expression / appearance / characteristic) due to environment;

2

(b) (i) 1. 3 and 4 and 9 / 11 / affected offspring;

1. Accept: 9 / 11 and their parents

1. Accept: unaffected parents have affected children

2. Both 3 and 4 are carriers / heterozygous;

2. Accept: if 3 and 4 are unaffected all their children will be unaffected

OR

If dominant at least one of 3 and 4 would be affected;

2

(ii) 1. 11 is affected, 3 is not;

1 Accept: 3 / unaffected father / parents produce an affected daughter

1. Accept: 3 and 4 would only produce unaffected females

2. 3 / father of 11 does not have a recessive allele on his X chromosome / X^t;

2. Answers must be in context of alleles

OR

(If on X) 11 / affected female would not receive the recessive allele on X chromosome / X^t from 3 / father;

Reject: recessive / dominant chromosomes

OR

(If on X) 3 / father (of 11) would pass on the dominant allele on his X chromosome / X^T;

2

(c) (i) Answer in range of 5.8 − 6.2% = 3 marks;;;

Answers in range of 0.058 - 0.062 = 2 marks

If incorrect answer, then 2 max of following points

1. q^2 / p^2 / tt = 0.001 or 1 divided by 1000;

2. p / q / T = 0.968 − 0.97;

3. Understanding that heterozygous = 2pq;

3. This can be shown mathematically ie 2 × two different numbers

3. Accept: answer provided attempts to calculate 2pq

3 max

(ii) Affected individuals (usually) do not reproduce / die during childhood / do not pass on allele / genetic screening;

1

[10] (a) (i) 1. No overall pattern / pattern (of right or left most

9 common) is not the same for all islands;

Allow expression in other ways e.g. three islands show left on top is more common

2. For **(B) C** and **E** there is little difference;

3. Large differences on **A** *and* **D** *and* opposite ways (to each other);

Need both aspects but allow other expressions of 'opposite ways'

2 max

(ii) 1. Can record all individuals on (small) islands;

2. (So) no / less sampling error;

3. (Maybe) different rates of mutation / different selection pressures /different environmental conditions;

4. Inbreeding / breeding with close relatives (more likely);

5. (Little) gene flow / (more chance of) genetic drift;*Accept reference to either of these ideas for this point*

2 max

(b) 1. If R is recessive, R × R parents cannot produce L offspring;
Accept use of genetic diagrams to illustrate points 1 and 2

2. If L is recessive, L × L parents cannot produce R offspring;*Accept right arm on top as R etc.*

3. R × R **and** L × L parents produce both types of offspring; *Need reference to two parent crosses for this mark*

3

(c) Both L and R in a set of twins / (some) twins show different arm-folding;

1

[8]

10 (a) 2.84:1;

Accept '2.84 to 1' or (just) 2.84
Do not accept 1:2.84 or 142:50

1

(b) 1. Some embarrassed / some not willing to show tongue / cannot tell;

2. Could not decide whether thumb was straight or not / thumb bending isjudgemental / subjective;

2

(c) 1. (No) - should be 92.9% / should be calculated from 182 out of 196 / should notbe calculated from 182 out of 200;
Allow either no or yes approach but no mark awarded for no or yes on its own

2. (Yes) – assumes 4 out of 200 use either hand;*Accept ambidextrous*

3. (But) sample may not be representative;
This could be expressed in other ways e.g. only based on one part of the country / might not be the same in different parts of the UK / might not be representative of UK

4. Small sample size / only sampled 200;

2 max

11

[5] (a) 1. Large number of eggs / offspring / flies (therefore) improves reliability / can use statistical tests / are representative / large sample (size) / reduces sampling error;

Each mark point requires a feature linked in mark scheme (by therefore) to an explanation

Do not accept a large number of eggs produces a large number of flies unless the term sample is used Ignore references to accuracy or precision

2. Small size / (breed) in small flasks / simple nutrient medium (therefore) reducescosts / easily kept / stored;

Accept small size so can be kept in small flasks

3. Size / markings / phenotypes (therefore) males / females easy to identify;*Answers must relate to size, markings or use the term phenotype*

4. Short generation time / 7 - 14 days / develop quickly / reproduce quickly (therefore) results obtained quickly / saves times / many generations;

2 max

(b) (i) 1. X^RX^R and X^rY;

All marking points are completely independent. Allow crosses from the following parents for a possible three marks:

X^RX^R and $X^rX^RX^R$

and X^rY;

RR and rY / rY⁻

RR and r− or RR and r

2. X^R and X^R plus X^r and Y;

3. X^RX^r and X^RY;

OR

1. X^RX^r and X^rY;

OR

X^RX^r and X^r−

X^RX^r and X^rY;

2. X^R and X^r plus X^r and Y;

Rr and rY / rY⁻

Rr and r⁻ or Rr and r

Accept different symbols e.g. W and w

2. Accept gametes in a punnet square

3. X^RX^r and X^RY;

3

(ii) Fertilisation is random / fusion of gametes is random / small / not large population / sample / selection advantage / disadvantage / lethal alleles;

Mutation = neutral

Random mating = neutral

Accept fertilisation / fusion of gametes is due to chance

1

(c) 1. Males have one <u>allele</u>;

Answers should be in context of alleles rather than chromosomes

2. Females need two recessive alleles / must be homozygous recessive / could have dominant and recessive alleles / could be heterozygous / carriers;

2

[8]

12 (a) Is always expressed / shown (in the phenotype);

Reject 'is always present' without further qualification

1

(b) C^BC^B, C^BC^P and C^BC^Y;

All three are required for the mark

<u>Or</u>

C^BC^B, C^PC^B and C^YC^B;

Accept C^BC^B, C^BC^P, C^BC^Y,

C^YC^B and C^PC^B

Accept BB, BP and BY <u>or</u>

BB, BP, BY, YB and PB

1

(c) 1. Two genotypes (as parents) shown as C^P C^Y

*Award **one mark maximum** for candidates who have misread the question and complete a correct genetic cross between a pink snail, C^PC^Y and a yellow snail, C^YC^Y to give pink and yellow offspring*

Or

Two sets of gametes shown as C^P and C^Y;

2. Genotypes of offspring shown as $C^P C^Y$, $C^P C^P$ and $C^Y C^Y$;

3. Above genotypes of offspring correctly linked to phenotypes i.e. pink andyellow;

Accept ratio (or equivalent) of 3 pink: 1 yellow for mark point 3

3

(d) 1. Correct answer of 42% = 3 marks

Answer of 0.42 = 2 marks

*Award **one mark maximum** for answer of 49.9 / 49.98 / 50% or 0.49 / 0.5*

2. q^2 = 0.49 / 49% ***OR*** q = 0.7 / 70%

*Award **one mark maximum** for answer of 40.8 / 41% or 0.41*

3. Shows understanding that 2pq = heterozygotes / carriers / shows answer isderived from 2pq;

Accept: b^2 = 0.49 / 49% or b = 0.7 / 70% for mark point 2

3

[8]

13

(a) (i) 1. Animal 2 / 5 has hair but offspring do not;

Accept parents as alternative to animals 2 and 5

2. So 2 / 5 parents must be heterozygous / carriers;

1 + 3: Allow reference to children / offspring for animals 7 + 8

OR

3. 4 / 7 / 8 are hairless but parents have hair;*Ignore reference to individuals 1 and 6*

4. So 2 / 5 must be heterozygous / carriers;

2

(ii) Hairless males have fathers with hair / 4 is hairless but 1 is hairy / 7 and / or 8 are hairless but 6 is hairy / only males are hairless;

Ignore references to other individuals

Ignore reference to genotypes

Allow credit for candidate who states that evidence is not conclusive / pedigree possible with autosomal character;

1

(b) 1. Parental genotypes
X^HX^h and X^HY
Gametes
X^H X^h X^H Y;

Accept any letter for gene but capital letter must represent dominant allele.

Both parental genotypes and gametes must be correct

2. Genotypes of offspringX^HX^H, X^HY, X^HX^h, X^hY;

Allow for offspring genotypes correctly derived from gametes given by candidate;

3. Phenotypes of offspringfemale with hair male with hair male hairless;

Allow phenotypes correctly derived from offspring genotype

Allow H ≡ X^H, h ≡ X^h

4. 0.25 / ¼ / 1 in 4 / 25 %

Ignore 1:3 in context of correct probability

Reject 1:4

4

[7]

14

(a) (i) 1. Parents are heterozygous;

Accept carriers / carries white allele

2. Kittens receive white allele from parents / black cat;

1 max

(ii) 1:1;

Answer must be expressed as a ratio that could be reduced to 1 : 1

1

(b) (i) Black,
Chocolate,
Black;

All three correct for the mark

1

(ii) Parental phenotypes Chocolate male Black female

1. Parental genotypes bb^i Bb^i;

Both genotypes needed for the mark.

1

2. Parental gametes b b^i B b^i;

Allow credit if gametes are correctly derived from candidate's incorrect parental genotypes.

1

3. Offspring genotypes Bb, Bb^i bb^i b^ib^i;

Genotype(s) must be with correct phenotype.

Allow credit if symbols other than B / b / b^i have been used correctly.

Ignore genetic diagrams unless clearly annotated.

1

Offspring phenotypes Black Chocolate cinnamon;

(iii) 1. Offspring ratios are a probability / not fixed / arise by chance /

2. gametes may not be produced in equal numbers /

3. fertilisation / fusion of gametes is random /

4. small sample;

1

(iv) 1. Possible if parents homozygous / bb;

2. Don't know genotype of chocolate cat / chocolate cat could be homo-orheterozygous / chocolate cat could be bb or bb^i;

3. Two chocolate cats could give cinnamon kittens;

2 max

[9

] (a) (i) Only expressed / shown (in the phenotype) when homozygous / two (alleles) are present / when no dominant allele / is not expressed when heterozygous;

15

1

(ii) Both alleles are expressed / shown (in the phenotype);

Allow both alleles contribute (to the phenotype).

1

(b) (i) Evidence (not a mark)

3 and 4 / two Rhesus positives produce Rhesus negative child / children / 7 / 9;

Explanation (not a mark)

Both Rhesus positives / 3 and 4 carry recessive (allele) / are heterozygous / if Rhesus positive was recessive, all children (of 3 and 4) would be Rhesus positive / recessive;

Do not negate mark if candidate refers to gene rather than allele.

Answers including correct and incorrect evidence = zero marks evidence and explanation.

2

(ii) Evidence (not a mark)

3 would not be / is Rhesus positive / would be Rhesus negative;

Explanation (not a mark)

3 would receive Rhesus negative (allele) on X (chromosome) from mother / 3 could not receive Rhesus positive (allele) from mother / 3 would not receive Rhesus positive (allele) / X (chromosome) from father / 1 / 3 will receive Y (chromosome) from father / 1;

OR

Evidence (not a mark)

9 would be Rhesus positive / would not be / is Rhesus negative /
8 and 9 / all daughters of 3 and 4 would be Rhesus positive;

Explanation (not a mark)

As 9 would receive X chromosome / dominant allele from father / 3;

Do not negate mark if candidate refers to gene rather than allele.

One mark for evidence and one mark for explanation linked to this evidence.

Any reference to allele being on Y chromosome negates mark for explanation.

2

(c) Correct answer of 48(%) = 3 marks;;;

q^2 / p^2= 16% / 0.16 / p / q = 0.4;

Shows that 2pq = heterozygotes / carriers;

Final answer of 0.48 = 2 marks

Allow mark for identifying heterozygotes if candidate multiplies incorrect p and q values by 2.

3

[9

16] (a) Cannot make (active) enzyme A (which converts precursor to linamarin) / cannot make linamarin;

1

(b) (i) **AL** + **Al** + **aL** + **al** ;

1

(ii) Meiosis separates alleles / homologous chromosomes / pairs of chromosomes;
Independent assortment / means either of **A** / **a** can go with either of **L** / **l**;

Accept "random segregation" but cancel if reference to crossing-over

2

(c) From parental genotypes: **AaLl** × **AaLl** (no mark)
Note: If wrong parental genotypes / wrong gametes: ALLOW correct derivation of offspring genotypes = 1 max

Correct derivation of offspring genotypes; max 2 marks if error in Punnett square

	AL	**Al**	**aL**	**al**
AL	AALL	AALl	AaLL	AaLl
Al	AALl	AAll	AaLl	Aall

aL	AaLL	AaLl	aaLL	aaLl
al	AaLl	Aall	aaLl	aall

Correct identification of offspring genotypes with at least one **A** and two **l** alleles (= grey cells in above table);
Correct proportion: 3 / 16 / 3:13 / 18.75% ;

3

(d) (i) There was no (significant) difference in damage between cyanogenic andacyanogenic / being cyanogenic has no effect;

1

(ii) The difference (from expected / from chance variation) is significant / difference / results not just due to chance;
Reject null hypothesis;
Being cyanogenic does help protect from slug damage;

3

(e) High slug population:
1. Find only cyanogenic plants / only cyanogenic plants survive;
2. (Cyanide release) limits / stops feeding by slugs / slugs killed;*Accept: converse argument re. acyanogenic plants*

Low slug population:
3. Find both types of plant;
4. Less selection pressure on plants from slugs / no selective advantage / noselection / described;

4

[15] (a) 1. Homologous chromosomes pair up / bivalents form;

17

2. Crossing over / chiasmata form;
3. Produces new combination of **alleles;**
4. Chromosomes separate;
5. At random;
6. Produces varying combinations of chromosomes / genes / alleles (*not twice*) ;
7. Chromatids separated at meiosis II / later;

Independent assortment / random segregation = marking points 4 and 5

6 max

(b) (i)

Parental phenotypes Agouti White

Parental genotypes BbAa bbaa ;

Gamete genotypes BA Ba bA ba ba ;

Offspring genotypes BbAa Bbaa bbAa bbaa ;

Offspring phenotype Agouti Black White White ;

Phenotypes must match genotypes

Allow marking points 2 and 3 if correctly derived from wrong parental genotypes

4

(ii)

Colour of offspring	***Observed (O)***	***Expected (E)***	***(O-E)***	***$(O-E)^2$***	***$\frac{(O-E)^2}{E}$***
Agouti	34	30	4	16	0.53
Black	35	30	5	25	0.83
White	51	60	9	81	1.35
			$\Sigma \frac{(O-E)^2}{E}$ = 2.71 or 2.72		

;; 2

(χ^2 correct = 2 marks)

($(O-E)^2$ all correct = 1 mark)

p = 0.05;
2 degrees of freedom;
Differences due to chance / no significant difference as χ^2 less than / to left of critical value OR Not due to chance / difference is significant as χ^2 greater than to right of critical value;

(as appropriate for candidates χ^2)

3

[15]

(a) Table completed as below:

18

Kingdom	Animalia / Animals
Phylum	Chordata
Class	Mammalia
Order	Rodentia
Family	Caviidae
Genus	*Cavia*
Species	*porcellus*

Column 1 correct;

Column 2 correct;

2

(b) Mutation occurs;

Correct e.g. of isolating mechanism
e.g.
temporal − different breeding seasons / feeding times /
ecological / behavioural − different courtship displays / different niches / habitats / feeding areas /
mechanical − mismatch of reproductive parts /
gamete incompatibility − sperm killed in female's reproductive tract /
hybrid inviability / hybrid infertility;
Ignore references to "genetic isolation" or "reproductive isolation"

Different selection pressures operate / changes in allele frequency / divergence of gene pools;

3

(c) Using candidate's symbols for alleles −
e.g. B = black, b = brown, S = short, s = long:

Parental genotypes <u>correct</u>: Male **A** SSBb Female **B** SsBB;

Gametes correctly <u>derived</u> from candidate's parental genotypes: SB Sb SB sB;

offspring genotypes correctly <u>derived</u> from candidate's suggested gametes − accept Punnett square or line diagram;

offspring genotypes correct: SSBB SsBB SSBb SsBb;

If monohybrid:cross ⇨ 0 marks

4

(d) There is no (significant) difference between observed and expected results / any differenceis due to chance;

1

[10]

19 parental genotypes correct: $\mathbf{X^RX^r}$ AND $\mathbf{X^RY}$; gametes correct for candidate's parental genotypes; offspring genotypes correct and colourblind male identified as $\mathbf{X^rY}$ / correct genotypes derived from cand's gametes and identify $\mathbf{X^rY}$; correct probability = ¼ / 0.25 / 25% / 1 in 4 / 1:3 ;

[4

] (a) (variation in) temperature will affect the solubility of oxygen / rate of respiration / use of

20

oxygen by cells / diffusion / gas exchange; *to gain credit point made must concern oxygen*

1

(b) (i) there is no difference between the partial pressure of oxygen in the two groups / the partial pressure of oxygen is the same in each group;

1

(ii) results may have been due to chance and statistical test allows us to determine the probability of this / of the difference between results being significant; enables acceptance or rejection of null hypothesis;
The key points here are chance and probability used in the correct context.

2

(c) **A**;
because partial pressure of oxygen only reduced when zinc in water / in **Y** / because when injected zinc / in **X** has no effect on partial pressure of oxygen in blood;

2

(d) less oxygen transport to cells / in fish / in blood;anaerobic respiration;
lactic acid produced / less carbon dioxide removed (from gills);
more H^+ ;

3 max

(e) (i) copper;calculation based on comparing concentration in woodlice with that in leaves;
accept any suitable method here, giving marks for the method and explanation. For example, calculating ratio of concentration in woodlice to concentration in leaves.

2

(ii) not absorbed from gut / passes out in faeces / egested / urine / excreted;

1

(iii) woodlice eat large amount of leaves;copper stored / accumulates in body;

2

(f) (i) mutation;

1

(ii) (as a component of) nucleic acids / DNA / RNA / nucleotides;phospholipids;
ATP / ADP;

2 max

(iii) arsenic-tolerant plants would not be able to take up phosphates / take up a littlephosphate; since likely to involve same mechanism / same carrier / protein;
(process of) growth would be poorer than non-tolerant plants;

3

[20]

21 (a) Parents genotypes Aabb aaBb ;

Gametes formed Ab ab aB ab ;
if parental genotypes wrong allow correctly derived gametes only

Offspring genotypes AaBb Aabb aaBb aabb

and

Offspring phenotypes 1 Walnut ; 1 Pea : 1 Rose : 1 single ;
*Just **one** mark for offspring genotypes **and** phenotypes*
If parents not diploid, no marks gained

3

(b) Correct answer 0.6, however derived, scores 2 marks
Wrong answer, but evidence of correct working
(e.g. $p^2 / q^2 = 0.36$) scores 1 mark

2

[5]

22 (a) (i) Two, as white blood cells are diploid cells / alleles are present on each chromosome of an homologous pair / one maternal and one paternal;

1

(ii) A **and** B

(reject I^A and $I^{B)}$

1

(b) 1 in 8 / 1 / 8 / 12.5% / 1:7 / 0.125;
(*Reject 1:8*) parents I^AI^O and I^BI^O ; give 1:3 / ¼ / 1 in 4 / 25% probability of blood group A and half will be male;

(accept 2nd and 3rd points from a suitable genetic diagram)

3

[5] (a) (i) where a change triggers a response which reduces the effect of a change;

23 **1**

(ii) e.g. sweating, breathing, defaecating, other valid example;

(reject respiration evaporation not acceptable as a 2nd mark if sweating or breathing given)

2 max

(iii) hypothalamus;

1

(b) (i) pituitary;

(ignore anterior pituitary)

1

(ii) 1. ADH causes vesicles containing aquaporins / aquaporins to be insertedinto membrane / collecting duct wall / plasma;
2. water enters cell through aquaporins;
3. by osmosis / diffusion / down a water potential gradient;
4. (from cell) to capillary;
5. via interstitial fluid;

4 max

(c) (i) excessive urination / drinking / diluted urine / thirst;

1

(ii) because males only have one X chromosome / do not have Y chromosome;a single copy of the recessive allele will be expressed;

2

(iii) recessive alleles can be carried by individuals without showing effects /dominant allele always expressed; organism that are carriers more likely to reproduce / affected organism less likely to reproduce; therefore recessive

alleles are more likely to be passed on / dominant alleles less likely to be passed on;

3

[15]