**Q1.**

(a)     What is meant by the term phenotype?

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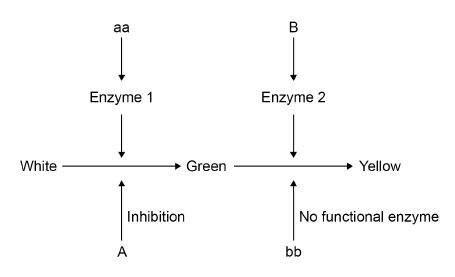
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**(2)**

(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.

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**(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)**

**(Total 7 marks)**

**Q2.**

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

|  |  |
| --- | --- |
| **Genotype** | **Phenotype** |
| **BbEe** | black |
| **bbEe** | chocolate |
| **Bbee** | yellow |
| **bbee** | yellow |

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

(i)      **BBEe** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

(ii)     **bbEE** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**(2)**

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

*Parental phenotypes*                      Black male           ×            Yellow female

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

*Gametes*

*Offspring genotypes*

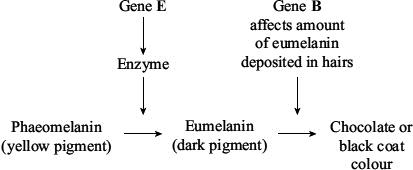
*Offspring phenotypes*

*Ratio of offspring*

*phenotypes*

**(3)**

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



Use this information to explain how

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

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**(2)**

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

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**(2)**

**(Total 9 marks)**

**Q3.**

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 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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Thumb \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(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.

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**(2)**

**(Total 5 marks)**

**Q4.**

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

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**(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** |  |
| Agouti | 34 |  |  |  |  |
| Black | 35 |  |  |  |  |
| White | 51 |  |  |  |  |
|  |  |  | Σ= | | |

**(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.

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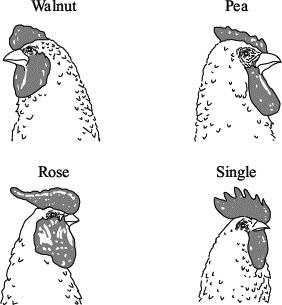
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**(3)**

**(Total 15 marks)**

**Q5.**

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** | The symbol **-** indicates that either the dominant allele or recessive allele could be present |
| **A- B-** | Walnut |
| **A- bb** | Pea |
| **aa B-** | Rose |
| **aa bb** | Single |

(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)**

**(Total 3 marks)**

**Q6.**

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.

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**(2)**

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

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**(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.

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**(1)**

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

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**(2)**

**(Total 7 marks)**

**Q7.**

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 **XA** leads to normal colour vision and the recessive allele **Xa** 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)**

**Q8.**

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 **CR** (red) and **CW** (white) control coat colour. When red cattle were crossed with white cattle all the offspring were roan. Roan cattle have a mixture of red and white hairs.

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

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(1)**

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

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**(1)**

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

*Parental phenotypes*             Horned, roan               ×               hornless, white

*Parental genotypes*

*Gametes*

*Offspring genotypes*

*Offspring phenotypes*

*Ratio of offspring*

*phenotypes*

**(4)**

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

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

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**(2)**

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

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**(1)**

**(Total 9 marks)**

**Q9.**

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.

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**(1)**

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

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**(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*

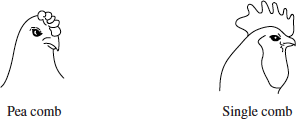
*Ratio of offspring  
phenotypes*

**(3)**

**(Total 6 marks)**

**Q10.**

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

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**(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?

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**(1)**

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

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**(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.

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**(2)**

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

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**(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 | XF XF | XfY |
| B | XF Xf | XfY |
| C | Xf Xf | XFY |
| D | XF Xf | XFY |

Answer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Explanation \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(3)**

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

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**(3)**

**(Total 14 marks)**