Exam questions for Monohybrid, Co-dominance and Multiple allele inheritance

**Q1.**

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

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**(1)**

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

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**(1)**

**Q2.**

Some cats have white patches on their coats. This effect is produced by the action of a spotting gene S. This gene has two co-dominant alleles, S1 and S2. The coats can have large patches of white, small white patches or no white patches at all.

A cat with no white patches, homozygous for S1, was mated with a cat that had small white patches. Some of the offspring produced had small white patches and the rest had no white patches at all. Complete a genetic diagram to show this cross and include the expected ratio of phenotypes on your diagram.

*Parental phenotype*s             \_\_\_\_\_\_\_\_\_\_\_                 \_\_\_\_\_\_\_\_\_\_\_

*Parental genotypes*                \_\_\_\_\_\_\_\_\_\_\_                 \_\_\_\_\_\_\_\_\_\_\_

*Gametes*                                 \_\_\_\_\_\_\_\_\_\_\_                \_\_\_\_\_\_\_\_\_\_\_

*Offspring genotypes*

*Offspring phenotypes*

*Ratio of phenotypes*

**(4)**

**Q3.**

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

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

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**(1)**

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

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**(1)**

(b)     The gene controlling coat colour has three alleles. The allele **B** gives black fur, the allele **b** gives chocolate fur and the allele **bi** gives cinnamon fur.

•        Allele **B** is dominant to both allele **b** and **bi**.

•        Allele **b** is dominant to allele **bi**.

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

|  |  |
| --- | --- |
| **Genotype** | **Phenotype** |
| **Bbi** |   |
| **bbi** |   |
| **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 phenotype*s             Chocolate male                 Black female

*Parental genotypes*                \_\_\_\_\_\_\_\_\_\_\_                 \_\_\_\_\_\_\_\_\_\_\_

*Gametes*                                 \_\_\_\_\_\_\_\_\_\_\_                \_\_\_\_\_\_\_\_\_\_\_

*Offspring genotypes*               \_\_\_\_\_\_\_\_          \_\_\_\_\_\_\_\_       \_\_\_\_\_\_\_\_

*Offspring phenotypes*Black             Chocolate      Cinnamon

**(3)**

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

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**(1)**

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

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**(2)**

**(Total 9 marks)**

**Q4.**

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, **CB**, is dominant to the other two alleles. The allele for pink, **CP**, is dominant to the allele for yellow, **CY**.

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

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**(1)**

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

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**(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)**

**(Total 8 marks)**

 **Q5.**

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

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**(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?

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**(1)**

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

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**(2)**

**(Total 10 marks)**

Exam questions for sex-linked inheritance

**Q6.**

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.

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2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(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.

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**(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.

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**(2)**

**(Total 8 marks)**

**Q7.**

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

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

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**(1)**

(b)     A male cat with the genotype **Xg Y** mates with a tortoiseshell female.

(i)      Give the phenotype of the male.

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**(1)**

(ii)     Give the genotype of the tortoiseshell female.

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**(1)**

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

*Parents* Male                     Tortoiseshell female

*Parental genotypes* **Xg Y**\_\_\_\_\_\_\_\_\_\_

  *Parental gametes*

*Offspring genotypes*

  *Offspring phenotypes*

  *Ratio*

 **(3)**

**(Total 9 marks)**

**Q8.**

(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            Grandfather         Grandmother      Grandfather
     (has antigen G)

*Genotypes*     \_\_\_\_\_\_or\_\_\_\_\_\_             \_\_\_\_\_\_                \_\_\_\_\_\_                \_\_\_\_\_\_

*Gamete*         \_\_\_\_\_\_or\_\_\_\_\_\_             \_\_\_\_\_\_                \_\_\_\_\_\_                \_\_\_\_\_\_
*genotype*

Father                                              Mother
                      (has antigen G)

*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 **XG** to show the presence of the allele for antigen G on the X chromosome, and **Xg** for its absence.

**(1)**

(ii)     Complete the rest of the diagram.

**(3)**

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

Probability \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

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

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**(2)**

**(Total 8 marks)**

**Exam questions for dihybrid inheritance**

**Q9.**

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?

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**(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.

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**(2)**

**(Total 7 marks)**

**Q10.**

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)**

**Autosomal Linkage Exam Questions**

**Q11.**

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

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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.



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)**

**Q12.**

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

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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.

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**(4)**

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

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**(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.

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**(2)**

**(Total 8 marks)**

**Exam questions for epistasis inheritance**

**Q13.**

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)**

**Q14.**

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 **Ah** codes for the production of a second form of the enzyme, which becomes inactive at temperatures close to a rabbit’s core body temperature, so only the face, ears, legs and tail are pigmented. A third allele, **a**, fails to code for a functional tyrosinase.

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

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

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

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**(2)**

(b)The table shows some genotypes and phenotypes.

|  |  |
| --- | --- |
| **Genotype** | **Phenotype** |
| **A–B–** | all fur black |
| **aaB–** | all fur white (albino) |
| **Ahabb** | white body fur with brown face, ears, legs and tail (Himalayan) |

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

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**(1)**

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

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**(2)**

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

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**(2)**

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

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**(2)**

**(Total 9 marks)**

**Q15.**

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.

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**(1)**

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

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

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**(1)**

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

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**(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.

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**(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?

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**(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 m2** | **Number of cyanogenic clover plants per m2** |
| 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.

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**(4)**

**(Total 15 marks)**