Q1.

In fruit flies, males have the sex chromosomes XY and the females have XX. In fruit flies, 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**.

(a) Male fruit flies are more likely than female fruit flies to have white eyes.

Explain why.

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(2)

(b) A female fruit fly with white eyes was crossed with a male fruit fly with red eyes to produce a large number of offspring.

Tick (✓) **one** box next to the statement which correctly describes the phenotypes produced from this cross.

All offspring red-eyed	☐
All females red-eyed, all males white-eyed	☐
All males red-eyed, all females white-eyed	☐
All males white-eyed, females red-eyed and females white-eyed	☐

(1)

In fruit flies, the genes for body colour and for wing development are **not** on the sex chromosomes. The allele for grey body colour, **G**, is dominant to the allele for black body colour, **g**. The allele for long wings, **L**, is dominant to the allele for short wings, **l**.

A geneticist carried out a cross between fruit flies with grey bodies and long wings (heterozygous for both genes) and fruit flies with black bodies and short wings.

The table below shows the results of this cross.

Phenotype of offspring	**Number of offspring**
Grey body **and** long wings	223
Black body **and** short wings	218

(c) Explain the results in the table above.

(3)

(d) The **first** generation of a population of fruit flies had 50 females.

Calculate how many female fruit flies would be produced from this population in the **fifth** generation.

You can assume:

- each female produces 400 offspring each generation
- half the offspring produced each generation are female
- there is no immigration or emigration
- no flies die before reproducing.

Show your working.

Give your answer in standard form.

Answer _______________

(3)
(Total 9 marks)

Q2.

(a) Mutation is one cause of genetic variation in organisms.

Give **two** other causes of genetic variation.

1 ____

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2 ____

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(2)

In a species of flowering plant, the **T** allele for tallness is dominant to the **t** allele for dwarfness. In the same species, two alleles $\mathbf{C^R}$ (red) and $\mathbf{C^W}$ (white) code for the colour of flowers. When homozygous red-flowered plants were crossed with homozygous white-flowered plants, all the offspring had pink flowers.

(b) Name the relationship between the two alleles that code for flower colour.

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(1)

(c) A dwarf, pink-flowered plant was crossed with a heterozygous tall, white-flowered plant.

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

Phenotypes of parents:	Dwarf, pink-flowered	×	Tall, white-flowered
Genotypes of parents:	________________		________________

Genotypes of offspring: ____

Phenotypes of offspring: ____

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Ratio of phenotypes: ____

(3)

(d) A population of this species of plant contained 9% of red-flowered plants.

Use the Hardy–Weinberg equation to calculate the percentage of pink-flowered plants in this population.

Show your working.

Answer ________________ %

(2)

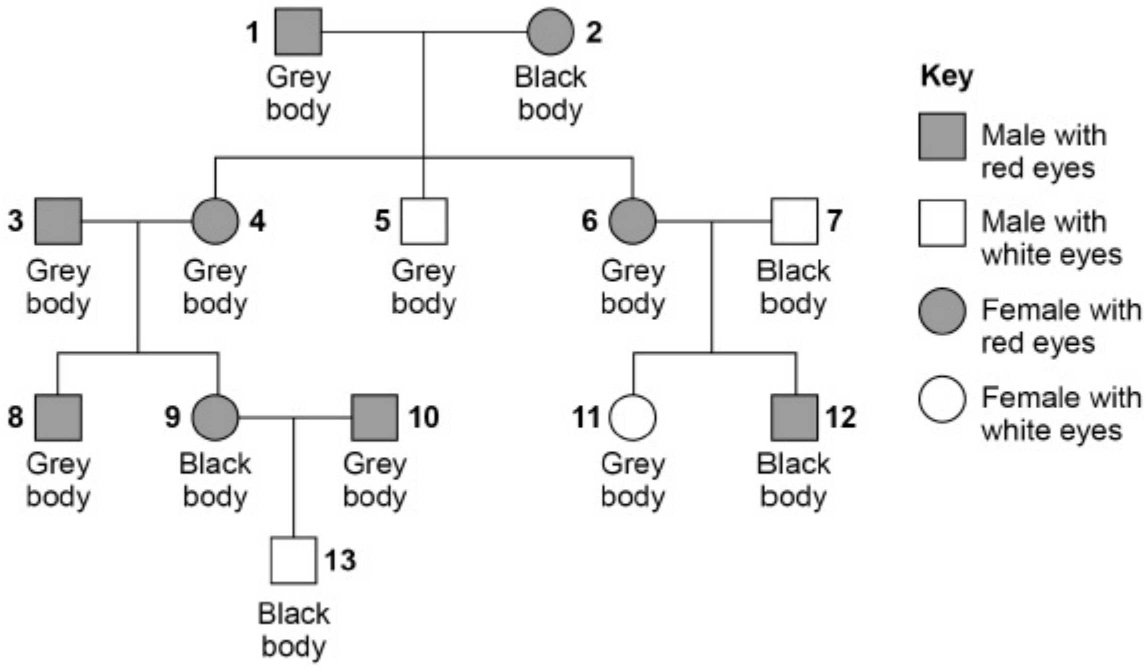
(Total 8 marks)

Q3.

In fruit flies, a gene for body colour has a dominant allele for grey body, **G**, and a recessive allele for black body, **g**.

A gene for eye colour has a dominant allele for red eyes, **R**, and a recessive allele for white eyes, **r**, and is located on the **X chromosome**.

The diagram shows the phenotypes of fruit flies over four generations.



(a) Give the full genotype of the fly numbered **6** in the diagram.

Genotype = ____

(1)

(b) Give **one** piece of evidence from the diagram above to show that the allele for grey body colour is dominant.

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(1)

(c) Explain one piece of evidence from the diagram above to show that the gene for body colour is **not** on the **X chromosome**.

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(2)

(d) A heterozygous grey-bodied, white-eyed female fly was crossed with a black-bodied, red-eyed male fly.

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

Phenotypes of parents:	Grey-bodied, white-eyed female	×	Black-bodied, red-eyed male
Genotypes of parents:	____________________	×	____________________

Genotypes of offspring ____

Phenotypes of offspring ____

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Ratio of phenotypes ____

(3)

(e) A population of fruit flies contained 64% grey-bodied flies. Use the Hardy–Weinberg equation to calculate the percentage of flies heterozygous for gene **G**.

Answer = ____%

(2)

(Total 9 marks)

Q4.

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

Suggest **two** reasons why.

1. ____

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2. ____

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(2)

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

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

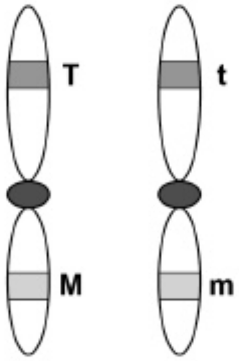

Table 1

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

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

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(1)

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

(3)

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

Table 2

Phenotype of offspring	**Ratio of offspring**

(2)
(Total 8 marks)

Q5.

(a) What is meant by the term phenotype?

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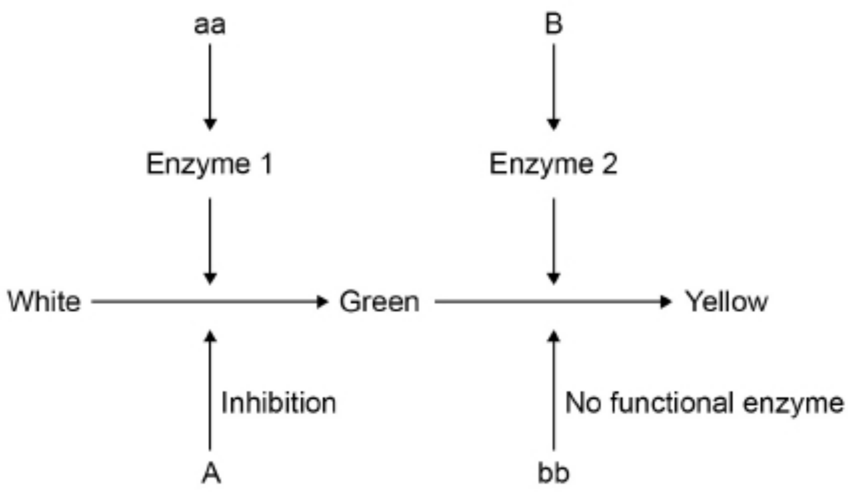
(2)

(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)

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

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

Answer = ____________ %

(2)

(Total 9 marks)

Q6.

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

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

Explain your answer.

Genotypes ____

Explanation ____

(2)

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

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

(1)

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

(2)

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

Which statistical test should she use?

(1)

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

What is meant by **codominant** alleles?

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(1)

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

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

Answer = ______________________

(1)

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

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

Answer = ______________________

(2)

(Total 10 marks)

Q7.

(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.

(4)

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

(1)

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

Give the reason for your choice of statistical test.

(2)

(Total 8 marks)

Q8.

Read the following passage carefully.

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

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

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

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

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

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

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(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** ____

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Couple **B** ____

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(4)

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

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(3)