16.2 The Roles of Genes in Determining the Phenotype

Question Paper

Course	CIE A Level Biology
Section	16. Inheritance
Topic	16.2 The Roles of Genes in Determining the Phenotype
Difficulty	Medium

Time allowed: 90

Score: /69

Percentage: /100

Question 1a

Shepherd's purse (*Capsella bursa-pastoris*) is a flowering plant that belongs to the mustard family. Fruit shape in this plant is determined by two alleles, namely allele **T** for a triangular fruit shape, which is dominant over allele **t** for top-shaped fruit. Two plants, both heterozygous for fruit shape, were crossed.

Complete the genetic diagram below (Fig.1) to show the results of this genetic cross.

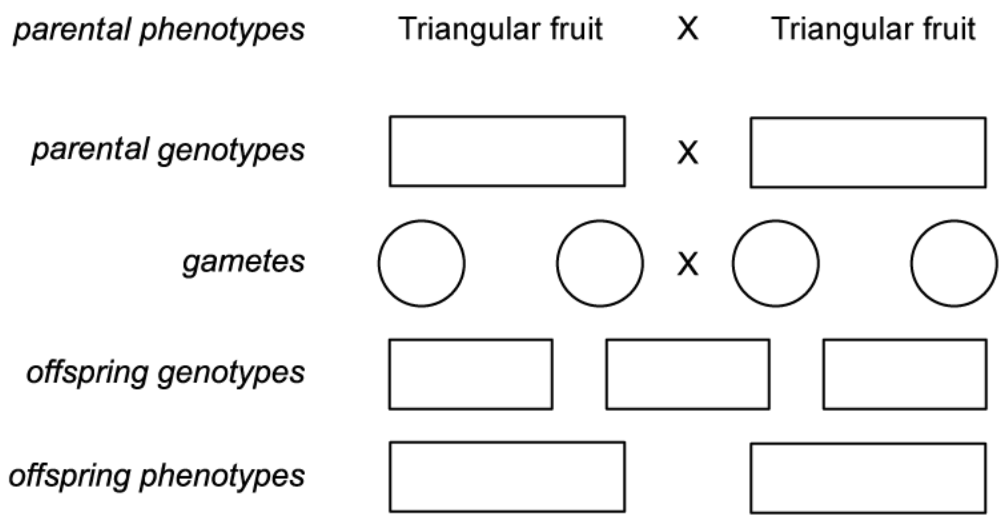

Fig. 1

[4 marks]

Question 1b

Explain why the parental phenotype was triangular shaped fruit with reference to their genotype.

[2 marks]

Question 1c

A plant with triangular shaped fruit was crossed with a plant that has top-shaped fruit. All 35 offspring of this cross had triangular shaped fruit.

State whether there can be a certainty that the original parent plant with triangular shaped fruit had a genotype of **TT** and provide a reason for your answer.

[2 marks]

Question 1d

The alleles for fruit shape in *C. bursa-pastoris* is an example of complete dominance.

Suggest the possible phenotype of heterozygous individuals if these alleles were codominant.

[1 mark]

Question 2a

Salvia is a plant that forms part of the sage family and contains almost 1 000 different species. Flower colour in *Salvia* is controlled by two genes, **A/a** and **B/b**, located on different chromosomes. Allele **B** gives rise to purple flowers and is dominant over the allele for pink flowers **b**. In order for these colours to be expressed in the phenotype allele **A** must be present as well, otherwise, the result is white flowers.

Table 1 lists some of the genotypes that are possible in *Salvia* plants.

Table 1

Genotype	Phenotype
AaBB	
AAbb	
aaBb	

Identify the phenotypes of the plants listed in Table 1.

[3 marks]

Question 2b

Explain the interaction between gene loci that is responsible for the phenotypes identified in part a).

[2 marks]

Question 2c

A homozygous pink-flowered *Salvia* is crossed with a homozygous white-flowered *Salvia* and all the offspring had purple flowers. Construct a Punnett square to show this cross.

[3 marks]

Question 2d

Two purple *Salvia* plants from the genetic cross from part c) were crossed.

State the phenotypic ratios of the F_2 generation.

[2 marks]

Question 3a

Aubergine (*Solanum melongena*) belongs to the same family as potatoes and tomatoes. They are a widely grown vegetable crop across Southeast Asia, Africa and the Mediterranean. Due to their importance as a food crop, scientists have been studying the inheritance of two genes (stem prickliness and fruit shape) that can have an influence on the profitability of the crop.

The allele **P**, for a non-prickly stem, is dominant over the allele **p**, for a prickly stem. The allele **R**, for round fruit, is dominant over the allele **r**, for linear fruit. The scientists examined 4000 offspring produced from the crosses between parent plants heterozygous for both genes.

Identify the missing phenotypes and genotypes of the offspring in Table 1

Table 1

Phenotype of the offspring	Genotype of the offspring
Non-prickly stem, linear fruit	
	PpRR
	ppRr
Prickly stem, linear fruit	

[2 marks]

Question 3b

State the expected phenotypic ratio for the genetic cross from part a) by completing Table 2, assuming that the genes were located on different chromosomes.

Table 2

Phenotype of offspring	Ratio of offspring

[4 marks]

Question 3c

The scientists found that the phenotypic ratios observed in the offspring did not correspond with the expected ratios listed in part b).

Suggest **two** possible reasons why the observed ratios do not reflect the scientists expected ratios.

[2 marks]

Question 3d

In some plant species, height is partially controlled by the ***Le*** gene. The allele ***Le*** produces tall plants and is dominant over allele ***le***, which produces short plants.

Explain the reason why the recessive allele ***le*** will result in short plants.

[3 marks]

Question 4a

Factor VIII is a coagulating agent that plays an important role in blood clotting and is coded for by the ***F8*** gene. There are abnormal alleles of this gene that lead to blood clotting abnormalities. A person that inherits these abnormal alleles will suffer from haemophilia. The ***F8*** gene is an example of a sex-linked gene.

Define the term 'sex-linked gene'.

[2 marks]

Question 4b

A gene, such as ***F8*,** can affect the phenotype of an organism.

Describe the mechanism by which the ***F8*** gene can affect the phenotype of a person.

[3 marks]

Question 4c

A woman that is a carrier of haemophilia and a haemophiliac male decide to have a child together.

Use the following symbols and complete the genetic diagram (Fig.1) showing the cross between them.

X^H = normal allele

X^h = allele for haemophilia

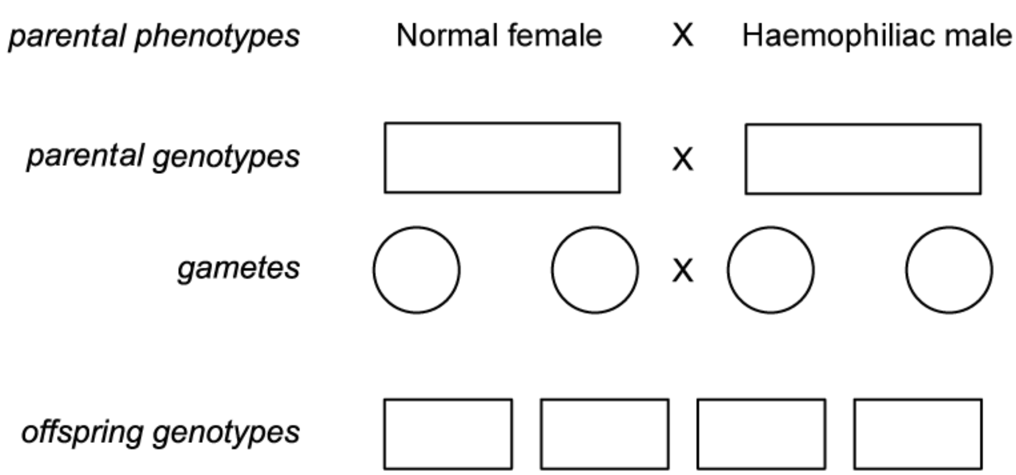

Fig. 1

[3 marks]

Question 4d

Haemophilia in male offspring will always be inherited from their mother.

Explain why it is impossible for male offspring to inherit haemophilia from their father.

[2 marks]

Question 5a

The black pigment melanin contributes to hair, skin and eye colour. Melanin is produced by cells known as melanocytes.

Tyrosinase is an enzyme involved in the production of melanin.

A study was carried out to investigate the effect of an extract of the starfish, *Patiria pectinifera*, on the activity of tyrosinase.

Table 1 shows the results of this study.

Table 1

Concentration of starfish extract / $\mu g\ cm^{-3}$	Percentage activity of tyrosinase
0	100
4	90
8	77
16	68
32	56
64	46
128	32

Suggest how the starfish extract affects the activity of tyrosinase.

[3 marks]

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Question 5b

The dominant allele of the *TYR* gene codes for the enzyme tyrosinase.

In people with albinism, the melanocytes do not produce melanin. This is caused by a recessive allele of the *TYR* gene.

(i)
Explain what is meant by the terms recessive and allele.

[2]

(ii)

Construct a genetic diagram to show how a man and a woman, who both produce melanin, could have a child with albinism.

Use appropriate symbols in your answer and state what they represent.

[3]

[5 marks]

Question 6a

Mammals such as sheep, *Ovis aries*, and goats, *Capra hircus*, are important agricultural animals that are sometimes kept together in mixed flocks. Very occasionally, live offspring are born from a mating between a male sheep and a female goat.

In sheep 2n = 54 and in goats 2n = 60.

(i)
Calculate the diploid chromosome number of the hybrid offspring of a sheep and a goat.

[1]

(ii)
Outline why the classification of sheep and goats suggests that hybridisation between them should **not** be likely to occur.

[1]

[2 marks]

Question 6b

Normal (wild-type) goats have a gold and black coat colour pattern, known as bezoar, and are also horned (have horns). Domestic goats may have a white coat and may be hornless (do not have horns).

These variations are coded for by two unlinked genes:

- white coat colour, coded for by the dominant allele of the gene **A/a.**
- hornless, coded by the dominant allele of the gene **H/h**.

A cross between a white hornless goat and a bezoar horned goat produced offspring of four different phenotypes.

Draw a genetic diagram to show the genotypes of the two parents, their gametes and the offspring, and the phenotypes of the offspring.

[4 marks]

Question 6c

Horns on agricultural animals such as goats and cattle can be dangerous to the farmer and to other animals. Horns are often prevented from growing in 5–day-old animals by a stressful procedure called disbudding.

Genetic modification can cause a deletion in the allele **h** coding for horns in cattle embryos, so that the allele no longer codes for a functional protein and the embryos grow into cattle that are hornless.

(i)

State an **ethical** advantage of this example of genetic modification.

[1]

(ii)

Suggest why genetic modification that causes a deletion in the horned allele, in established breeds of dairy cattle, is preferable to selective breeding for hornless animals.

[1]

[2 marks]

Question 7a

Gibberellin is a plant growth hormone that has a role in germination and in stem elongation.

Outline how gibberellin is involved in activating genes for stem elongation.

[2 marks]

Question 7b

Outline the role played by gibberellin in the germination of wheat seeds.

[4 marks]

Question 7c

The length of stem in pea plants is controlled by a single gene. Pea plants can be either tall or short.

A study was carried out to investigate the effect of applying gibberellin to short pea plants.
Two groups of short pea seedlings were used, group **P** and group **Q**.

- Group **P** consisted of 20 seedlings to which a paste containing gibberellin had been applied two days after germination.
- Group **Q** consisted of 20 seedlings to which a paste **without** gibberellin had been applied two days after germination.
- The length of stem of the pea plants was recorded at intervals over 20 days.

The results are shown in Fig. 1.

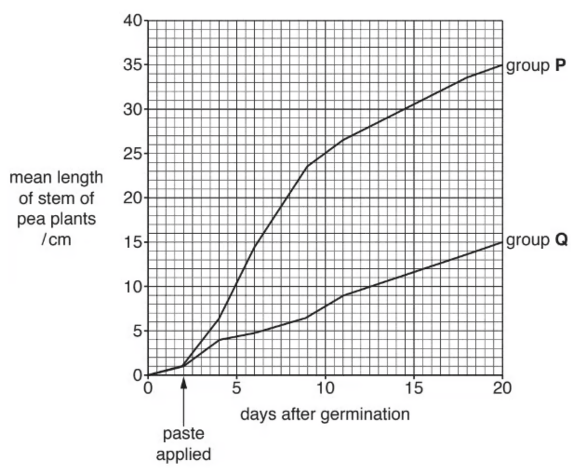

Fig.1

With reference to Fig. 1, describe the results of the investigation **and** compare the growth rate of plants in group **P** and group **Q**.

[4 marks]

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Question 7d

Explain the role of the gene controlling stem length in pea plants.

[3 marks]