The roles of genes in determining the phenotype

Question Paper 1

Level	International A Level
Subject	Biology
Exam Board	CIE
Topic	Inherited change
Sub Topic	The roles of genes in determining the phenotype
Booklet	Theory
Paper Type	Question Paper 1

Time Allowed : **81 minutes**

Score : **/ 67**

Percentage : **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 Deer mice, *Peromyscus maniculatus*, are small rodents that live in North America. Like all mammals, their blood contains haemoglobin which combines with oxygen in the lungs, and unloads its oxygen in respiring tissues.

Deer mice show variation in their genotypes for the genes that code for the α-polypeptide chain of haemoglobin. In most populations of deer mice, the majority of individuals have the genotype A^1A^1, while a smaller number have the genotype A^0A^0.

(a) In mice with the genotype A^1A^1, the amino acid at position 64 in the α-polypeptide chain is aspartic acid. In mice with the genotype A^0A^0, the amino acid at this position is glycine.

Suggest how the change from aspartic acid to glycine in the α-polypeptide chain could have been brought about.

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(b) The genotypes of deer mice from three different populations, each living at a different altitude, were analysed. Fig. 5.1 shows the relative proportions of deer mice with aspartic acid (white areas) and glycine (black areas) at position 64 in the α-polypeptide of their haemoglobin.

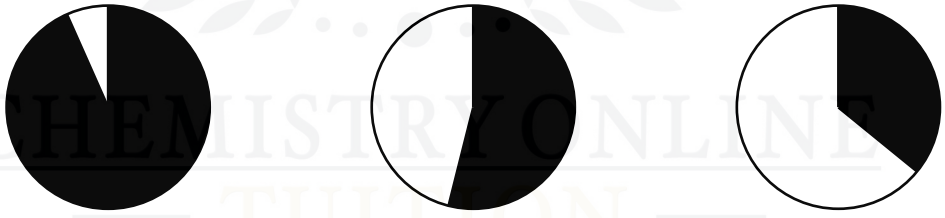

Fig. 5.1

(i) Describe the effect of altitude on the frequency of the haemoglobin alleles in these populations of deer mice.

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(ii) The partial pressure of oxygen is relatively low at high altitudes. Haemoglobin containing glycine at position 64 in the α-polypeptide chain has a higher affinity for oxygen than haemoglobin with aspartic acid at this position.

Suggest how natural selection could account for the difference in allele frequency in deer mice living at high altitudes and low altitudes.

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[Total: 8]

2 A group of membrane proteins which transport sugars out of cells have been identified and called SWEETs. They are found in the cell surface membranes of both animal and plant cells, including mammalian liver cells and rice mesophyll cells.

Each SWEET is a protein with seven coiled regions which together make a pore through a membrane bilayer as shown in Fig. 3.1.

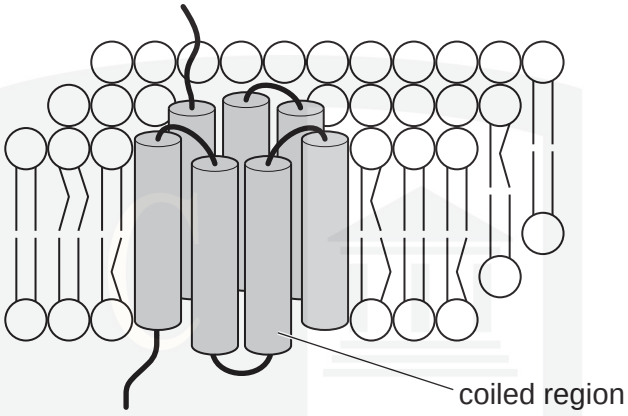

Fig. 3.1

(a) (i) Explain why, to enter or leave a cell, sugars need molecules such as SWEETS.

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(ii) Suggest how a SWEET is held within the membrane bilayer.

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(b) The bacterium, *Xanthomonas oryzae* (Xoo), causes the disease known as bacterial leaf blight in rice plants. It infects the intercellular spaces of the leaves of the host plant. Then, by switching on *SWEET* genes in the mesophyll cells, it stimulates the secretion of glucose into the intercellular spaces.

Several different **recessive** alleles have been found, in rice plants from different countries, which give resistance to bacterial leaf blight. All these alleles have a mutation in the promoter of the *SWEET* gene.

The effect of Xoo on wild type and resistant rice plants is compared in Fig. 3.2.

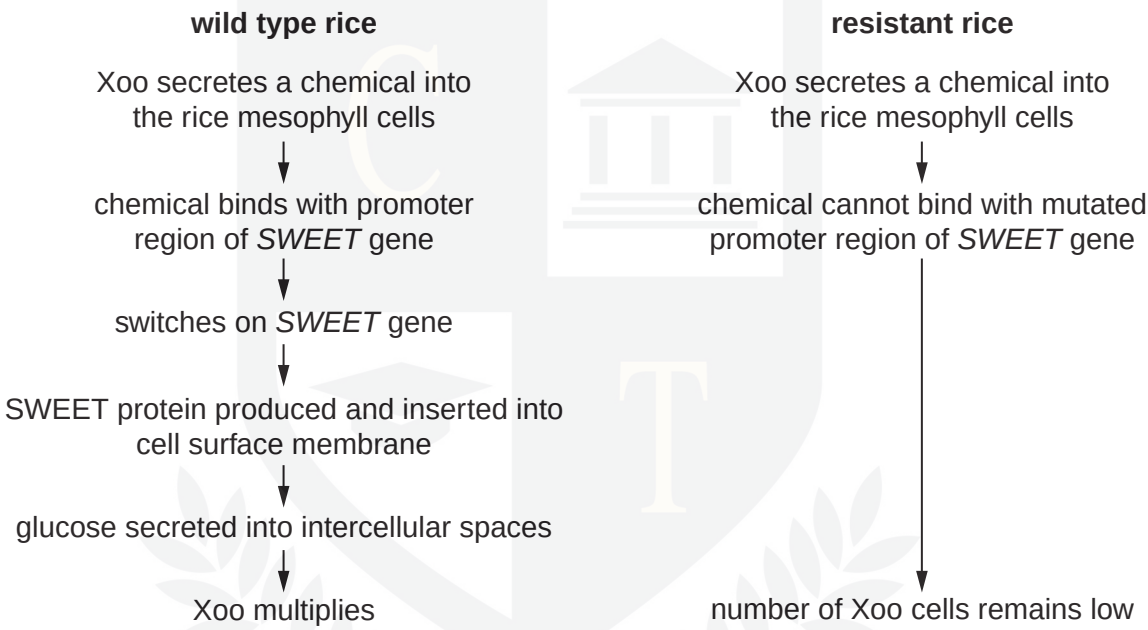

Fig. 3.2

(i) Using the information in Fig. 3.2, explain this resistance of rice plants to Xoo.

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(ii) Explain why it would be difficult to transfer this resistance into susceptible rice plants by genetic engineering.

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(iii) Explain why the presence of large numbers of Xoo in the intercellular air spaces of rice plants affects the ability of the plants to grow with their roots submerged in water.

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[Total: 14]

3 The fruit fly, *Drosophila melanogaster*, has many phenotypic variations and has been used in experiments to demonstrate the principles of inheritance.

(a) The majority of fruit flies have red eyes but there is a variant with white eyes.

Fig. 7.1 shows the red-eyed and white-eyed variants of the fruit fly.

Fig. 7.1

The gene for eye colour is located on the X chromosome.

Using suitable symbols, draw a genetic diagram to show the possible offspring of a cross between a heterozygous red-eyed female fruit fly with a white-eyed male fruit fly.

key to symbols:

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parental phenotypes	red-eyed female	white-eyed male
parental genotypes		
gametes		
offspring genotypes		
offspring phenotypes		

[5]

(b) One of the genes controlling the clotting of blood in humans is also located on the X chromosome. A rare variation of the gene, a recessive allele for haemophilia, can lead to a condition where the blood fails to clot properly.

(i) State why a man who has haemophilia is unable to pass the condition on to his son.

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(ii) Queen Victoria of Great Britain in the 19th century was a carrier of haemophilia, but did not have the condition.

State the term used to describe the genotype of a carrier.

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(iii) Neither of Queen Victoria's parents carried the allele for haemophilia.

Suggest how Queen Victoria could have become a carrier.

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[Total: 8]

4 **(a)** Explain the advantages to a plant species of cross-pollination compared to self-pollination.

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(b) Some of the most important food plants for humans depend on insect pollinators, such as the honeybee, *Apis mellifera*.

Fig. 7.1 shows a honeybee.

Fig. 7.1

5 **(a)** Fig. 4.1 shows the male and female flowers of maize.

Fig. 4.1

(i) With reference to Fig. 4.1 suggest how the flowering habit of maize encourages wind pollination.

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(ii) In a maize plant, the anthers normally ripen and release pollen before the stigmas are mature and ready to receive pollen. This encourages cross-pollination.

Explain **two** potential advantages of cross-pollination to a plant species.

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(b) The conditions in which wheat and maize are grown affect their ability to photosynthesise.

Fig. 4.2 compares the rate of photosynthesis of wheat and maize at different temperatures.

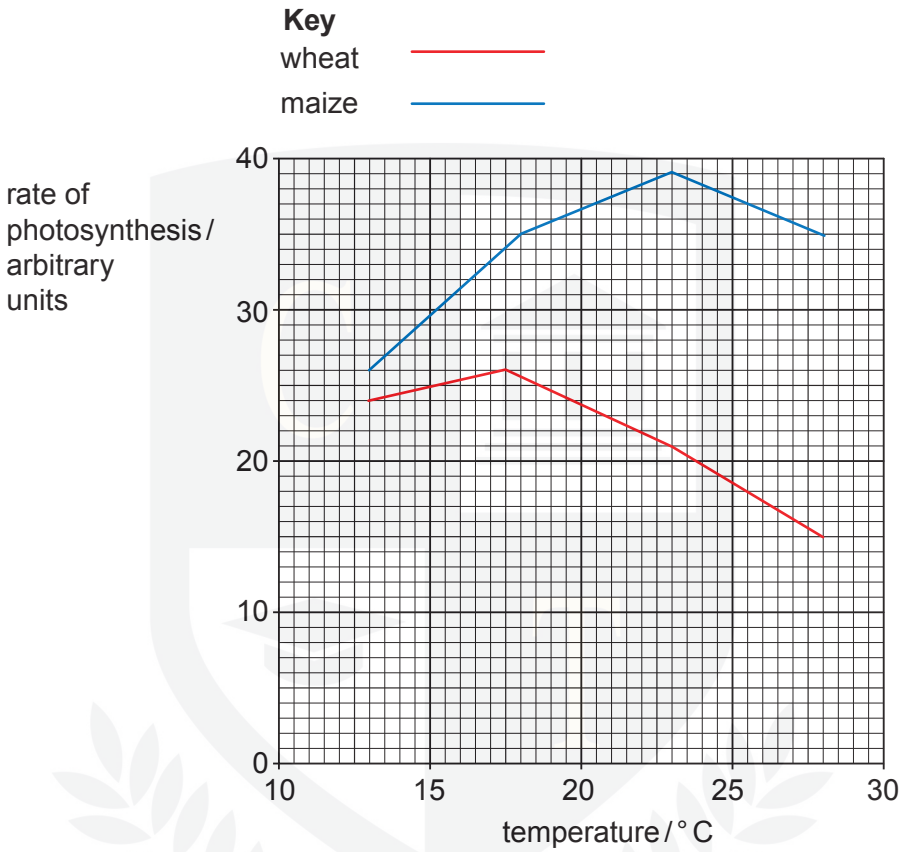

Fig. 4.2

With reference to Fig. 4.2:

(i) **compare** the effect of temperature on the rates of photosynthesis of wheat and maize

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(ii) explain the difference between the rates of photosynthesis of wheat and maize at **28 °C**.

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(c) Cereal grains are a major component of the human diet.

Table 4.1 shows some of the nutrient contents of 100 g samples of grains of wheat, white rice and maize.

Table 4.1

	wheat	**white rice**	**maize**
protein / g	12.3	7.5	8.9
fat / g	2.0	2.8	4.7
carbohydrate / g	75.0	77.0	74.0
fibre / g	2.3	0.9	2.0
calcium / mg	34.0	28.0	7.0
iron / mg	5.4	1.6	2.7
sodium / mg	2.0	6.0	35.0

(i) With reference to Table 4.1 suggest reasons for the difference in protein content between wheat and white rice.

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(ii) State, giving a reason, which type of grain would be beneficial for a person with anaemia.

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[Total: 14]

6 **(a)** Explain how changes in the nucleotide sequence of DNA may affect the amino acid sequence in a protein. [8]

(b) Explain how the allele for haemophilia may be passed from a man to his grandchildren. You may use genetic diagrams to support your answer. [7]

[Total: 15]