Natural and Artificial Selection

Question Paper 5

Level	International A Level
Subject	Biology
Exam Board	CIE
Topic	Selection and evolution
Sub Topic	Natural and artificial selection
Booklet	Theory
Paper Type	Question Paper 5

Time Allowed: 59 minutes

Score : /49

Percentage : /100

Grade Boundaries:

A*	А	В	С	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

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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 $lpha$ -polypeptide chain could been brought about.	

(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.

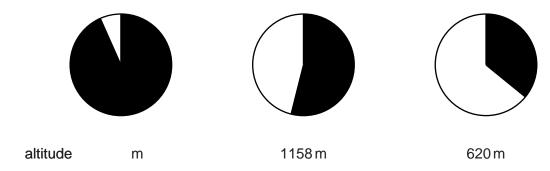


Fig. 5.1

(i)	Describe the effect of altitude on the frequency of the haemoglobin alleles in these populations of deer mice.
	[2]
(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.
	[4]

[Total: 8]

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2 (a) The summer squash plant produces fruit that are either white or yellow in colour and are either shaped like a disc or a sphere. The dominant phenotypes are white and disc-shaped fruit. Using the symbols A for white and a for yellow and B for disc and b for sphere, draw a genetic diagram to show what proportion of offspring will have yellow and sphere-shaped fruit if a white and disc-shaped fruit plant, heterozygous for both genes, is self-fertilised.

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Sickle cell anaemia is a blood disease that is frequently fatal when homozygous. It is caused by an autosomal recessive allele. Heterozygotes have sickle cell trait and appear normal.

Malaria is a potentially fatal infectious disease of the blood caused by the protoctist, *Plasmodium*. In parts of the world where malaria is endemic the frequency of the sickle cell allele is high.

(b) Explain the possible health consequences, in such areas, for a person who is homozygous dominant and for a person who is homozygous recessive for the sickle cell

	alle	le.
	(i)	homozygous dominant for the sickle cell allele
		[1]
	(ii)	homozygous recessive for the sickle cell allele.
		[1]
(c)	Exp	olain why heterozygotes have a strong selective advantage in areas where malaria urs.
		[3]

[Total: 11]

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The evolutionary origin of the four-legged amphibians (such as frogs and toads) from fish has been the subject of much debate for many years.

Among living fish, the rarely-caught coelacanth and the lungfish are thought to be most closely related to these amphibians.

Samples of blood were taken from two coelacanths that were captured recently near Comoros.

The amino acid sequences of the α and β chains of coelacanth and lungfish haemoglobin were compared with the known sequences of amphibian adults and their aquatic larvae (tadpoles). Organisms with more matches in the amino acid sequence of a polypeptide chain share a more recent common ancestor than those with fewer matches.

The comparisons with three species of amphibians, *Xenopus laevis (XI), X. tropicana (Xt) and Rana catesbeiana (Rc)* are shown in Table 2.1.

Table 2.1

		percentage of matches of amino acid sequence					
			species o hibian ac		•	es of amp larvae (tadpoles)	
	fish species	XI	Xt	Rc	ΧI	Xt	Rc
ahaina	coelacanth	42.0	47.5	no data	45.4	42.6	48.2
α chains	lungfish	40.4	42.1	no data	40.7	39.0	37.9
0 oboino	coelacanth	42.1	43.2	40.7	52.1	52.1	58.2
β chains	lungfish	44.1	45.9	41.4	47.3	45.9	48.6

(a)

(i)	Explain whether or not the information in Table 2.1 supports the suggestion that coelacanths and amphibians share a more recent common ancestor than do lungfish and amphibians.
	[4]

	(ii)	Suggest why adults and tadpoles of the same species of amphibian have different amino acid sequences in their haemoglobin.
		[2]
(b)	whi	elacanth haemoglobin has a very high affinity for oxygen, suggesting that coelacanths, ch have been captured at depths of between 200 m and 400 m, live in water that has w concentration of oxygen.
	-	lain how an environmental factor, such as the low concentration of oxygen in deep er, can act:
	(i)	as a stabilising force in natural selection
		[3]
	(ii)	as an evolutionary force in natural selection.
		[3]

ain the role of isolating mechanisms in the evolution of new species.	(c)
[3]	
[Total: 15]	

4	(a)	Describe how crossing over and independent assortment can lead to genetic variation.[9]
	(b)	Outline how artificial selection differs from natural selection. [6]
		[Total: 15]