Questions

Q1.

The genetic condition Hers disease is caused by a recessive allele of the glycogen phosphorylase gene.

In an isolated population of 1400 people in the USA, 15 people have Hers disease.

(i) Calculate the number of heterozygous individuals in this population.

Use the Hardy-Weinberg equation

(4)

$$p^2 + 2pq + q^2 = 1$$

Answer ....

(ii) The frequency of Hers disease in most human populations is 1 in 40 000.

Explain why the frequency of Hers disease is higher in the isolated population.

(2)

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(Total for question = 6 marks)

Q2.

The diagram shows four varieties of rabbit.

Brown   Chinchilla   Himalayan   Albino

Fur colour in rabbits is controlled by four different alleles:

- the allele for brown fur, C, is dominant to all other alleles
- the allele for chinchilla fur, c^{ch}, is dominant to the alleles for Himalayan and albino
- the allele for Himalayan fur, c^h, is dominant to the allele for albino
- the allele for albino fur, c, is recessive to all other alleles

The fur colour of animals can be affected by natural selection.

Compare and contrast stabilising selection with disruptive selection.
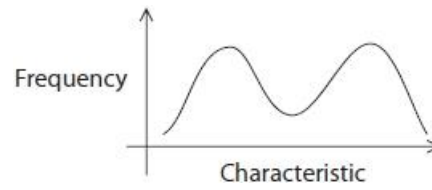
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(Total for question = 3 marks)

Q3.

The graph shows the frequency of a characteristic found in a population of animals.

Which type of selection would create this pattern?

(1)

☒ **A** allopatric selection
☒ **B** directional selection
☒ **C** disruptive selection
☒ **D** stabilising selection

(Total for question = 1 mark)

Q4.

Gilbert's potoroo is one of the most critically endangered species in the world.

Gilbert's potoroo was thought to be extinct until one was found in 1994.

It is thought that there are only 70 individuals.

The photograph shows a potoroo and its pouched baby feeding on berries.

The map shows the only part of Australia where Gilbert's potoroo is found.

In 1994, there were only 20 Gilbert's potoroo individuals, 12 of which were in a captive colony.

A captive breeding programme was set up using:

- four adult females and one young female
- one adult male, two young males and one young male still in its mother's pouch.

(i) Explain why allele frequencies may cause problems in this population of potoroos.

(3)

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(ii) Foxes and feral cats, which are predators of potoroos, were introduced into Australia by settlers.

The photograph shows a feral cat with its prey.

The Australian government is using poisoned sausages in an attempt to kill 2 million feral cats by 2020.
The sausages contain chunks of kangaroo meat combined with chicken fat, herbs, spices and a poison.
The content of the sausages was based on flavours irresistible to cats.
The poison used is produced by the Swan River pea plant that is found in Western Australia. Other Australian plants that contain the poison are: *Acacia*, Wedge Peas and *Nemcia*.
This poison is a natural toxin that biodegrades rapidly and the native wildlife in Australia has evolved natural resistance to it.
A group of 160 000 people in Australia have signed a petition against the plan to poison feral cats.
Discuss whether the plan to poison feral cats is justified.

(9)

(Total for question = 12 marks)

Q5.

The photograph shows an insect fossilised in amber resin.

(Source: Bjoern Wylezich. 123rf.com/PAL)

Scientists have classified another fossilised insect found in amber resin as a new species of mosquito, *Priscoculex burmanicus*.

This mosquito is anatomically very similar to modern species of mosquito.

Mosquito populations are often controlled using pesticides that inhibit the enzyme acetylcholinesterase.

Long-term use of pesticides often leads to the development of resistance in these mosquitoes.

The ace-1 gene codes for the enzyme acetylcholinesterase.

The ace-1^r allele is a recessive form of this gene that gives resistance to pesticides.

The changes in the numbers of resistant and non-resistant mosquitoes in an area of farmland where pesticides were used in 2007 was investigated.

The use of the pesticides was stopped in 2016.

The table shows the results of this investigation.

Mosquito type	Number of mosquitoes		
	2005	2015	2018
resistant	125	5250	4120
non-resistant	8755	1250	3950

(i) Calculate the number of heterozygous mosquitoes in 2015.

Use the Hardy-Weinberg equation

$$p^2 + 2pq + q^2 = 1$$

(3)

Answer ....

(ii) Explain why the changes in the numbers of the resistant and non-resistant mosquitoes, from 2005 to 2018, are related to the function of the ace-1 gene.

(4)

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(Total for question = 7 marks)

Q6.

The Eurasian lynx is the largest native European cat species.

It was once widespread across Europe but is now restricted to small areas of national parks.

Ex-situ and *in-situ* conservation measures were used in the 1970s to increase biodiversity.

- Lynx were bred in zoos and 10 were reintroduced into an area of protected forest where the lynx had become extinct.
- Existing wild lynx were protected in an area of forest where they had not become extinct.

In 2016 scientists estimated the population sizes and genetic biodiversity of the lynx in these two areas of forest.

They found that the population and genetic biodiversity of the lynx in the area where they had been reintroduced were much lower than in the protected area.

(i) State what is meant by the term **biodiversity**.

(1)

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(ii) Explain why, in 2016, the genetic biodiversity of the lynx population in the area where they had been reintroduced was much lower than in the protected area.

(2)

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(Total for question = 3 marks)

Q7.

There are many disorders that affect the health of people.

The graph shows the number of people in the world who die each year from different health disorders.

Deaths in millions per year

* Some health disorders, such as sickle cell anaemia, have a genetic basis.

People who are at risk of these disorders can be identified using genetic tests.

Hospital managers need to predict the future cost of treating people with health disorders.

It has been claimed that the Hardy-Weinberg equation ($p + q = 1$ or $p^2 + 2pq + q^2 = 1$) could be used to predict the number of people who would need treatment for health disorders.

Discuss the validity of this claim.

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(Total for question = 9 marks)

Q8.

Cystic fibrosis is a recessive inherited condition where the cells in the lungs produce sticky mucus. This mucus builds up in the airways, causing breathlessness and chest infections.

People with cystic fibrosis often need treatments such as physiotherapy and antibiotics.

The incidence of babies born with cystic fibrosis in Australia is 1 in 2500.

Use the Hardy Weinberg equation, $p^2 + 2pq + q^2 = 1$, to calculate the percentage of Australians who are carriers of cystic fibrosis.

(4)

Answer .... %

(Total for question = 4 marks)

Q9.

Tibetan populations have a recessive allele that helps them to survive at high altitude.

In a village in Tibet, 1950 people out of a population of 2500 people carry two copies of this allele.

(i) Calculate the number of heterozygous people in the village.

Use the Hardy-Weinberg equation

$$p^2 + 2pq + q^2 = 1$$

(3)

Answer ....

(ii) This allele is currently found only in human populations in Tibet.

The allele has also been found in the fossil bones of an extinct form of modern humans called the Denisovans.
Fossils of Denisovans have been found in Tibet.
Explain why scientists think that the Denisovans belonged to the same species as modern humans.

(2)

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(Total for question = 5 marks)

Q10.

Palm plants and cocoa plants are used to produce lipids for the food industry.

Palm oil is produced from palm plants. Cocoa butter is produced from cocoa plants.

Some forests in Borneo have been cleared to grow these plants.

Orangutans used to live in forests throughout this island but now they are found in small areas of forest.

The map shows the distribution of orangutans in parts of Borneo.
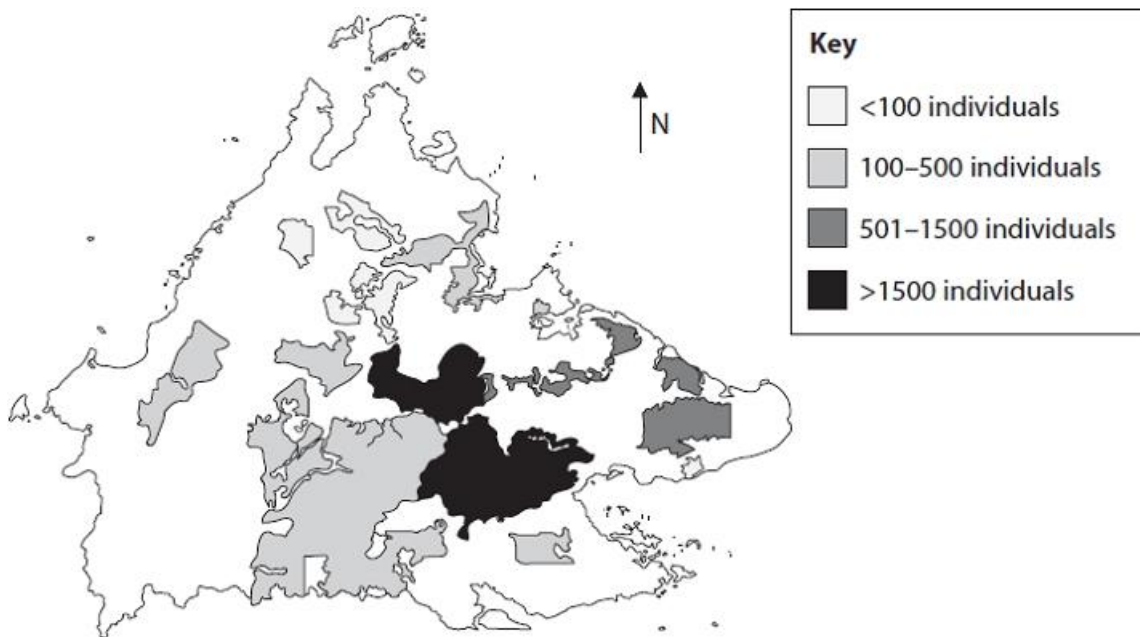
(i) Explain why in areas with low populations of orangutans, many of the orangutans have deformities and health problems.

(2)

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(ii) The Malaysian government is paying local people to create and maintain 'land-bridges' of forest to link areas of forest together.

Explain why these payments will help to develop palm oil production and support conservation of orangutans.

(3)

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(iii) State how treaties such as CITES help conserve orangutans.

(1)

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(Total for question = 6 marks)

Q11.

The Northern elephant seal is a mammal found in the Eastern Pacific Ocean.
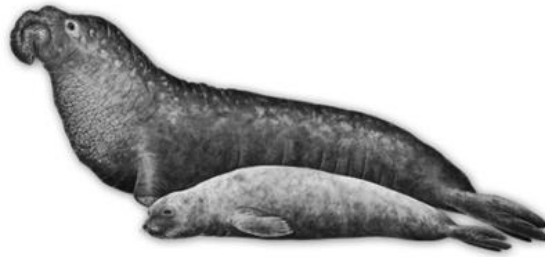
In the nineteenth century, Northern elephant seals were hunted and this reduced the population to about 20 seals.

The seals were listed as an Appendix II species when CITES was established in the 1970s.

The population has now recovered to over 100 000 individuals.

The seals in this population have developed health problems, including a high mortality rate for newborn pups, deformities and weak immune systems.

(i) Describe the role of treaties such as CITES in maintaining global biodiversity.

(2)

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(ii) Explain why, although the population of seals has recovered, many of the seals have health problems.

(2)

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(Total for question = 4 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	A calculation that makes reference to three of the following: • calculation of q^2 • calculation of p and q • calculation of 2pq • calculation of the number of heterozygotes in a population of 1400 252 to 260 (4)	Example of calculation $15 \div 1400 = 0.0107$ $p = 0.897$ $q = 0.103$ $2pq = 2 \times 0.897 \times 0.103 = 0.185$ $0.185 \times 1400 = 259$ Correct answer with no working gains full marks **ACCEPT** one mark for: $q^2 = 0.01$ to 0.0107 $p = 0.897$ to 0.9 **and** $q = 0.1$ to 0.103 **ACCEPT** $2pq = 0.18$ to 0.187 in final answer for **3** marks	4

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: • founder effect (1) • therefore genetic bottleneck / therefore small gene pool (1) • more likely to receive two recessive alleles (from parents) / both parents are more likely to be heterozygous / carriers (1)	**ACCEPT** low genetic diversity / small number of different alleles	2

Q2.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to three of the following:		
	• both change the frequency of alleles / change genetic diversity (1)	**Accept** change gene pool	
	• both select against (less well adapted) phenotypes (1)	**Accept** converse **Accept** alleles for phenotypes **Do not accept** genes	
	• disruptive selection selects against {middle / mean / median} phenotypes but stabilising selection selects against extreme phenotypes (1)	**Accept** converse **Accept** alleles for phenotypes **Do not accept** genes	
	• disruptive selection leads to {two distinct populations / bimodal distribution} but stabilising selection maintains one population (1)	**Accept** clear labelled diagrams	(3)

Q3.

Question Number	Answer	Mark
	The only correct answer is C *A is not correct because allopatric selection is an incorrect term* *B is not correct because directional selection would move the curve in one direction* *D is not correct because stabilising selection would result in one peak*	(1)

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to three of the following: • the numbers are very small causing a genetic bottle neck (1) • so that variation in the gene pool may have been reduced (1) • causing increased likelihood of inbreeding effects (1) • such as accumulation of disadvantageous mutations (1)	Allow reference to founder effect Allow small gene pool Allow inbreeding depression, Allow early offspring may have comefrom only one male Allow greater chance of receiving tworecessive alleles	(3)

(ii)

Level	Marks	
0	0	No awardable content
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context withgeneralised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas,processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge andunderstanding to the given context.
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevantbiological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientificideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevantknowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range ofscientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear andlogically structured.

ii	Justification for using poison to kill feral cats
Applying marking points These are indicative marking pointsand other relevant information should be credited **Level 1** 1 mark: any point 2 marks: any two points3 marks: any 3 points **Level 2** 4 marks: 4 points, must have +and - 5 marks: 5 points, must have +and - 6 marks: 6 points, must have +and - **Level 3** Points must come	1. less potoroos killed (+) 2. potoroos less likely to become extinct (+) 3. feral cats are an introduced species (+) 4. there are very large numbers of feral cats (+) 5. increased fungal spread in ecosystem (by potoroos) (+) 6. introduced species will be killed but native species unharmed (+) 7. biodiversity remains higher if native species not killed (+) 8. sausages are designed to target cats (+) 9. native species less likely to become extinct (+)10.poison is biodegradable (+)
	Reasons not to kill feral cats with poison 1. pets may be killed (-) 2. other animals may be killed (-) 3. lots of people object to this (petition) (-) 4. sausages could be attractive to wild species as well (-) 5. government could use other methods to reduce population of feral cats (-) 6. suggested other methods eg spaying, shooting (-) 7. killing cats does not deal with threat from foxes (-) 8. plants / kangaroos are killed to make the poison (-) 9. feral cats are behaving naturally and should not be punished for this (-)

from all threesections 7 marks: 7 points, must have +and - 8 marks: 8 points, must have +and – 9 marks: 9 points, must have +and -	**Wider points** 1. poison made from native plants so less likely to kill native animals (+) 2. biodegradable poison so action now will not affect animals in the future (+) 3. potoroos require special protection as there are such small numbers /endangered (+) 4. idea of balance needed in ecosystem (+) 5. cats have no natural predators in Australia, so it is justified to kill them (+) 6. ethics of government choosing which species to kill (-) 7. government could continue the breeding programme for potoroos (-) 8. effect on food chain of killing 2m feral cats (positive or negative) 9. feral cats may develop resistance to the poison (-) 10. government could try a small-scale trial to find effects of cull (-)

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	A calculation that makes reference to: • correct calculation to find q (1) • correct calculation to find p (1) • correct calculation to find 2pq and number of mosquitoes (1)	q = 0.899... **Allow** any dpp = 0.101... **Allow** any dp **Allow** ecf for mp2 and mp3 1183 = three marks Correct answer with no working gainsfull marks	3

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to four of thefollowing:		
	• The frequency of the resistance allele increased in 2015 (1)	**Allow** Number of resistant mosquitoesincreases in 2015 **Allow** converse	
	• because the (resistant) acetylcholinesterase enzyme is not affected by the pesticide / enzymestill works (1)	**Allow** converse **Allow** converse	
	• acetylcholine is still broken down in synapses (1)	**Allow** resistant mosquitoes are at a selective advantage	
	• the mosquitoes survive and breed (1)		
		Allow lost by genetic drift / non- resistant mosquitoes out compete resistant ones after pesticide use stops	
	• the resistance allele carries a cost as it is reducedwhen no pesticide is used / after 2015 (1)	**Allow** no selective pressure to retain the resistant allele	4

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	different {alleles} in a gene pool / species / population OR different {species} in an {area / habitat / environment / ecosystem / community}	**ACCEPT** genetic variation within a species	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • only small number / 10 introduced / {founder effect / genetic bottleneck} has occurred / (1) • (resulting in a) limited gene pool / few different alleles / inbreeding in zoos / no other lynx present to provide new alleles (1)	**ACCEPT** converse for lynx in protected area **ACCEPT** converse for lynx in protected area **DO NOT ACCEPT** diversity of alleles	**(2)**

Q7.

Question Number	Indicative content
*	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Candidates are expected to reach a decision/conclusion on whether the Hardy Weinberg equation could be used to predict the number of people in the future who would need treatment in the UK for health disorders. **Lifestyle (L)** • HW only predicts genetic disorders • many health disorders are not genetic / caused by lifestyle • example of a lifestyle disease **Formula and Assumptions (A)** • assumes frequency of alleles remains constant / $p + q = 1$ refers to allele frequency • assumes frequency of genotypes remains constant / $p^2 + 2pq + q^2 = 1$ refers to genotype frequency • p^2 = homozygous dominant / $2pq$ = heterozygotes / q^2 = homozygous recessive • assumes no selection / random mating • assumes no mutation • assumes no migration • assumes large population / no genetic drift

Problems (P)
- recognises assumptions invalid
- explain why assumptions are invalid
- understands that countries have different population sizes
- people unwilling to have a genetic test / risks with genetic tests / tests need to be done
- genetic testing is expensive
- cannot test for all alleles
- understands that environment can affect gene expression

Level	Marks	
0	0	No awardable content
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. **1 to 3 from L A or P (only one of L A or P)**
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure. **4 to 6 from L A or P (from at least two of L A or P)**
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. **7 plus from L and A and P**

Q8.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: • calculation of q^2 (1) • calculation of p and q (1) • calculation of 2pq (1) • calculation of percentage of carriers (1)	Example of calculation: q^2= 0.0004 / 4×10^{-4} q = 0.02 and p = 0.98 2pq = 0.0392 percentage of population who are carriers is 3.92% Correct answer with no working gains full marks	**(4)**

Q9.

Question Number	Answer	Additional Guidance	Mark
(i)	• calculation of q (1) • calculation of p (1) • calculation of number of heterozygotes (1)	Correct answer: 516 **Accept** answers with range of 517 and 528 with incorrect rounding for two marks Correct answer gains full marks **Accept** ECF for mp3 for 2pq x 2500	3

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • only Tibetans and Denisovans have the allele (1) • so (the presence of the allele) suggests that Denisovans and Tibetans must have interbred (1) • and produced fertile offspring (1)	**Accept** Allele is present in Tibetans and Denisovans	2

Q10.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to two from the following: • a genetic bottleneck has occurred (1) • resulting in a smaller gene pool (1) • so the probability of receiving two recessive alleles is higher (1)	 **Accept** lower genetic diversity **Accept** inbreeding / higher chance of two organisms have similar alleles	 2

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three from the following: • therefore animals from different populations can move across territories / forest to forest (1) • therefore increasing genetic diversity / widens gene pool / increased allele number (1) • and balances the needs of local people with conservation / retains jobs for local people (1) • local people are more likely to maintain the bridges (1)	 **Accept** animals from different forests can move in / more outbreeding	 3

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to one from the following: • {banning export / import trade of species} preventing {poaching / illegal trapping} (1)	 **Accept** {countries} sign treaty / agree preventing {poaching / trapping / exports / imports / trade}	 1

Q11.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to two of the following: • CITES prevents {exploitation / hunting / sale / trade / poaching} (1) • by countries that sign up to the treaty (1) • by {protecting / conserving} endangered species (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: • (genetic / population) bottleneck (1) • causing reduced {genetic diversity / gene pool / number of different alleles} (in populations) (1) • therefore the chance of inheriting two harmful recessive alleles increases (1)	**Accept** small / restricted gene pool	**(2)**