FREE SAMPLE: THE FIRST QUESTION

Question One (15 marks)

(a) In a population of 400 individuals, 20.3% are people with the condition (the recessive phenotype of one gene; the population is assumed to be in Hardy–Weinberg equilibrium).

(i) Calculate the frequency of the recessive allele (q) and the dominant allele (p).

(ii) Calculate the expected number of heterozygous individuals in the population.

(iii) The environment changes so that individuals with the recessive phenotype have a relative fitness of 0.20 compared with 1.00 for the other genotypes. Calculate the frequency of the recessive allele in the next generation, and explain how natural selection changes the allele frequencies.

[8 marks]

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(b) The table shows the number of individuals in each size class of the shell thickness of a snail in a population before and after a change in the environment.

(i) Calculate the mean value of the trait before and after the change.

(ii) Name the type of natural selection that has occurred.

(iii) Explain how the selection pressure produced this change in the population.

Shell thickness (mm)	3	4	5	6	7	8	9
Number before selection	5	19	38	62	39	20	8
Number after selection	1	5	30	91	30	6	2

[7 marks]

THE WORKED ANSWER TO THAT QUESTION

Question 1 (15 marks) [Allele frequencies and selection]

(a) In a population of 400 individuals, 20.3% are people with the condition (the recessive phenotype of one gene; the population is assumed to be in Hardy–Weinberg equilibrium). (i) Calculate the frequency of the recessive allele (q) and the dominant allele (p). (ii) Calculate the expected number of heterozygous individuals in the population. (iii) The environment changes so that individuals with the recessive phenotype have a relative fitness of 0.20 compared with 1.00 for the other genotypes. Calculate the frequency of the recessive allele in the next generation, and explain how natural selection changes the allele frequencies.

(a) Answer: (i) q = 0.450, p = 0.550; (ii) 198 heterozygotes; (iii) new q = 0.344

- Evidence level: Excellence (q^2 = frequency of the recessive phenotype; p + q = 1; 2pq = heterozygotes; selection changes the gene pool).
- (i) $q^2 = 0.203$, so $q = \sqrt{0.203} = 0.450$ and $p = 1 - 0.450 = 0.550$.
- (ii) $2pq = 2 \times 0.550 \times 0.450 = 0.495$, so the number of heterozygotes = $0.495 \times 400 = 198$.
- (iii) After selection, the mean fitness = $1 - q^2(1 - w) = 1 - 0.203 \times 0.80 = 0.8380$. New $q = (pq + q^2w) \div$ mean fitness = $(0.248 + 0.0405) \div 0.8380 = 0.344$ (a fall from 0.450).
- Achievement: States that selection reduces the recessive allele frequency.
- Merit: Links to survival and reproduction: individuals with the recessive phenotype have a lower chance of surviving and reproducing, so fewer recessive alleles are passed on.
- Excellence: Full explanation: the phenotype of the recessive homozygotes reduces their fitness, so they contribute fewer offspring to the next generation; the proportion of recessive alleles in the gene pool falls (from 0.450 to 0.344), though not to zero because recessive alleles carried in heterozygotes are hidden from selection; this is natural selection changing allele frequencies, the basis of evolution.

> **KEY TAKEAWAY**
> Hardy–Weinberg: p + q = 1 and $p^2 + 2pq + q^2 = 1$; q = √(frequency of the recessive phenotype); selection against a genotype lowers its alleles' frequency by an amount found from the mean fitness.

(b) The table shows the number of individuals in each size class of the shell thickness of a snail in a population before and after a change in the environment. (i) Calculate the mean value of the trait before and after the change. (ii) Name the type of natural selection that has occurred. (iii) Explain how the selection pressure produced this change in the population.

(b) Answer: (i) 6.06 and 6.03 mm; (ii) stabilising selection

- Evidence level: Excellence (compare the means and the spread (standard deviation) before and after).
- (i) Mean before = 6.06 mm; mean after = 6.03 mm. (Spread: standard deviation 1.35 then 0.891.)
- (ii) Stabilising selection: the mean is unchanged but the spread has decreased (the extremes have been lost).
- Achievement: (iii) States which phenotypes survived and reproduced.
- Merit: Links to inheritance: the favoured individuals pass their alleles to the next generation in greater numbers.
- Excellence: Full explanation: individuals with intermediate values had the highest fitness, while extremes were less likely to survive or reproduce, so alleles for extreme phenotypes were selected

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against and the population became more uniform around the mean

KEY TAKEAWAY

Types of selection: directional (mean shifts), stabilising (extremes lost, mean unchanged), disruptive (extremes favoured, two peaks). Calculate the mean as Σ(number × value) ÷ total.

LOS: Allele frequencies and selection (91605)

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