1.7 Genetics, Populations, Evolution and Ecosystems: 30-minute Pack

AQA 7402 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A sample of a diploid plant species shows two alleles at a locus for petal colour: A (dominant red) and a (recessive white). In a randomly mating large population, the frequency of the recessive phenotype (white) is measured as 4.0%.

(a) Assuming Hardy-Weinberg equilibrium, calculate the allele frequency q for a and p for A given that the recessive phenotype frequency is 4.0%. Show working and give frequencies to 3 significant figures. **(4)**

(b) Calculate the expected percentage of heterozygotes (Aa) in the population. Give your answer to 3 significant figures. **(3)**

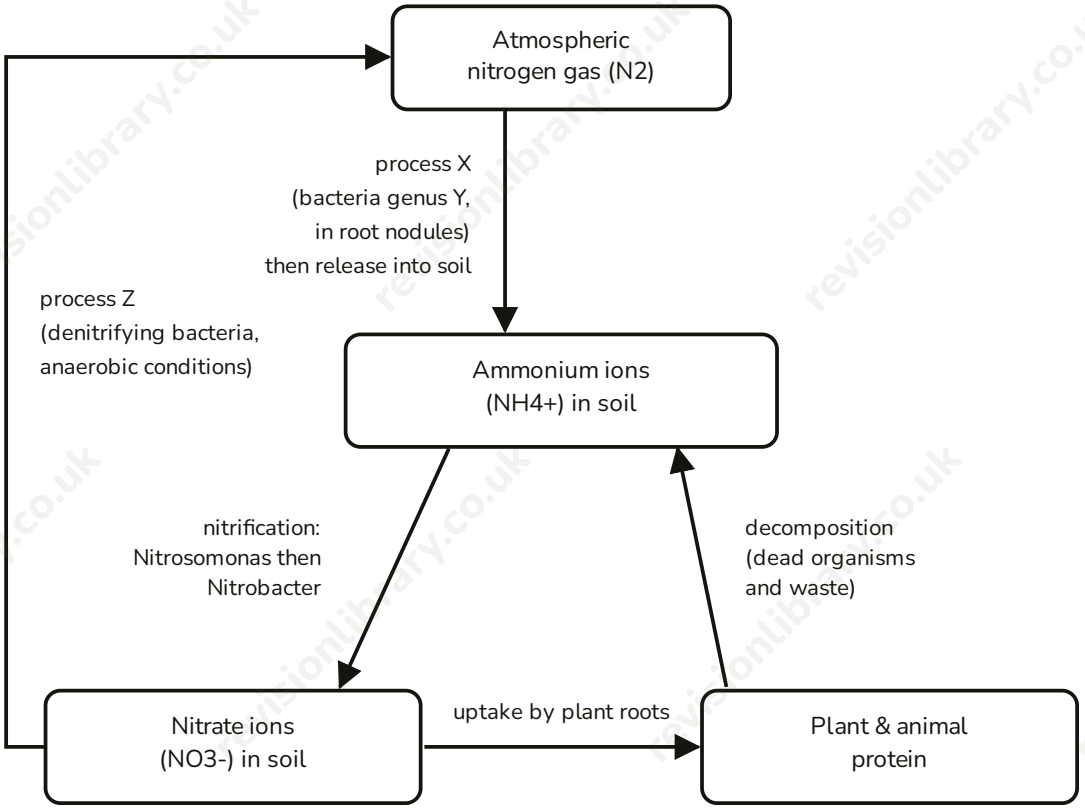
(c) Use a chi-squared test with the sample of 500 plants (observed white = 28) to test HWE at 5% significance. Use 1 degree of freedom. Show your calculations and conclude whether the population is in equilibrium. Use expected frequencies from (a) and (b). **(7)**

(Total for Question 1 is 14 marks)

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2 The diagram below summarises part of the nitrogen cycle in a farmland ecosystem.
Atmospheric nitrogen gas (N_2) --[process X, via bacteria genus Y in root nodules; followed by release into soil]--> Ammonium ions in soil --[nitrification: Nitrosomonas then Nitrobacter]--> Nitrate ions in soil --[uptake by plant roots]--> Plant/animal proteins --[decomposition of dead organisms and waste]--> Ammonium ions in soil.
Nitrate ions in soil --[process Z, denitrifying bacteria, under anaerobic conditions]--> Atmospheric nitrogen gas (N_2).

Nitrogen cycle in a farmland ecosystem



(a) Name process X in the diagram and the genus of bacteria (Y) responsible for it. **(2)**

(b) Explain the roles of Nitrosomonas and Nitrobacter bacteria in the nitrogen cycle. **(3)**

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(c) Explain why waterlogged soil reduces the availability of nitrate ions to plant roots. **(3)**

(Total for Question 2 is 8 marks)

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Mark scheme · 1.7 Genetics, Populations, Evolution and Ecosystems: 30-minute Pack

Question 1

(a) use $q^2 = 0.04$ or equivalent **M1**

(a) $q = \sqrt{0.04} = 0.200$ **M1**

(a) p = 1 - q = 0.800 **M1**

(a) final frequencies q = 0.200 and p = 0.800 to 3 s.f., cao **A1**

(a) Answer: q = 0.200, p = 0.800

(b) substitute p and q into 2pq = 2 x 0.800 x 0.200 **M1**

(b) evaluate 2 x 0.800 x 0.200 = 0.320 **M1**

(b) 2pq = 0.320 = 32.0% to 3 s.f., cao **A1**

(b) Answer: 32.0%

(c) calculate expected numbers: expected white = q^2 x 500 = 0.04 x 500 = 20; expected non-white = 480 **M1**

(c) set up chi-squared for two categories: sum (observed - expected)^2 / expected **M1**

(c) compute contribution for white: $(28 - 20)^2 / 20 = 64/20 =$ 3.20 **M1**

(c) compute contribution for non-white: $(472 - 480)^2 / 480 =$ 64/480 = 0.1333 **M1**

(c) sum contributions = 3.3333 and compare with critical value 3.84 at 1 d.f., oe **M1**

(c) state conclusion: chi-sq 3.33 < 3.84 so do not reject H0; population not significantly different from HWE at 5% significance **M1**

(c) clear statement of conclusion with comparison to critical value, cao **A1**

(c) Answer: Chi-squared = 3.33; since 3.33 < 3.84 at 1 d.f., do not reject HWE; the sample is consistent with Hardy-Weinberg equilibrium at 5% significance.

Question 2

(a) nitrogen fixation **B1**

(a) Rhizobium **B1**

(a) Answer: Process X = nitrogen fixation; bacteria genus Y = Rhizobium (in root nodules of legumes).

(b) Nitrosomonas oxidise ammonium ions to nitrite ions oe **B1**

(b) Nitrobacter oxidise nitrite ions to nitrate ions oe **B1**

(b) together these nitrifying bacteria convert ammonium into nitrate (nitrification), a form of nitrogen that can be absorbed by plant roots and used to build amino acids/proteins/nucleic acids oe **B1**

(b) Answer: Nitrosomonas oxidise ammonium to nitrite; Nitrobacter oxidise nitrite to nitrate; this nitrification produces nitrate, the form of nitrogen that plants can absorb and use to build proteins and nucleic acids.

(c) waterlogged soil contains little or no oxygen (anaerobic conditions) oe **B1**

(c) anaerobic conditions favour denitrifying bacteria, which convert nitrate ions into nitrogen gas (denitrification), removing nitrate from the soil oe **B1**

(c) nitrifying bacteria (Nitrosomonas/Nitrobacter) require oxygen and cannot function well in anaerobic conditions, so less nitrate is produced from ammonium in the first place, further reducing nitrate availability to plant roots oe **B1**

(c) Answer: Waterlogging creates anaerobic conditions, which favour denitrifying bacteria (converting nitrate to N_2 gas) and inhibit oxygen-requiring nitrifying bacteria, so nitrate is both removed and produced more slowly, reducing availability to plants.

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