# 1.7 Genetics, Populations, Evolution and Ecosystems: 1-hour Pack

Total Marks

AQA 7402 · Calculator allowed · about 60 minutes

Name: _____ Date: ____ / ____ / _____

**Answer ALL questions. Show all your working.**

**1** In a UK grassland ecosystem, producers (grass) had a gross primary productivity (GPP) of 20000 kJ $m^{-2}$ $yr^{-1}$. The producers used 8000 kJ $m^{-2}$ $yr^{-1}$ of this energy in respiration.

**(a)** Using the equation NPP = GPP - R, calculate the net primary productivity (NPP) of the grass. **(2)**

**(b)** Primary consumers (e.g. rabbits and insects) in this grassland converted 1200 kJ $m^{-2}$ $yr^{-1}$ of this NPP into their own biomass. Calculate the percentage efficiency of energy transfer from producers to primary consumers. **(2)**

**(c)** Secondary consumers in this grassland (e.g. shrews and small birds) obtained 150 kJ $m^{-2}$ $yr^{-1}$ of energy from feeding on the primary consumers. Calculate the percentage efficiency of energy transfer from primary consumers to secondary consumers, and state which of the two trophic transfers calculated in this question was more efficient. **(3)**

**(d)** Explain why the percentage of energy transferred between trophic levels in an ecosystem is generally low. **(2)**

**(Total for Question 1 is 9 marks)**


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**2** Ecologists compared the biodiversity of two adjacent habitats using Simpson's Index of Diversity: $D = 1 - \text{sum}[(n/N)^2]$, where n = number of individuals of a species and N = total number of individuals of all species recorded.

Habitat A (ancient woodland): 75 individual plants recorded: 15 oak seedlings, 10 birch seedlings, 20 bramble plants, 5 ferns and 25 bluebells.

Habitat B (adjacent monoculture wheat field): 100 individual plants recorded: 90 wheat plants, 5 of weed species 1, 3 of weed species 2 and 2 of weed species 3.

**(a)** Calculate the value of Simpson's Index of Diversity (D) for Habitat A. Show your working. **(3)**

**(b)** Calculate the value of Simpson's Index of Diversity (D) for Habitat B. **(2)**

**(c)** Using your calculated values, compare the biodiversity of the two habitats and suggest one reason for the difference. **(3)**

**(Total for Question 2 is 8 marks)**


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**3** The ability to taste a bitter-tasting compound called PTC is controlled by a single gene, with the allele for tasting (T) dominant to the non-tasting allele (t). In a sample of a UK population, 16% of individuals were found to be non-tasters. Assume this population is in Hardy-Weinberg equilibrium for this gene.

**(a)** State the Hardy-Weinberg equations that link (i) allele frequencies and (ii) genotype frequencies. **(2)**

**(b)** Calculate the frequency of the non-tasting allele (t) in this population. **(2)**

**(c)** A different town has a population of 8500 people in Hardy-Weinberg equilibrium for this gene, with the same allele frequencies as above. Calculate the number of people in this town who are heterozygous carriers of the non-tasting allele. **(3)**

**(d)** State two assumptions that must be true for a population to be in Hardy-Weinberg equilibrium. **(2)**

**(Total for Question 3 is 9 marks)**

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**4** Genetic drift is the random change in allele frequencies from one generation to the next, due to chance rather than natural selection. Two examples of genetic drift are the founder effect and the population bottleneck effect.

**(a)** Define the term genetic drift. **(1)**

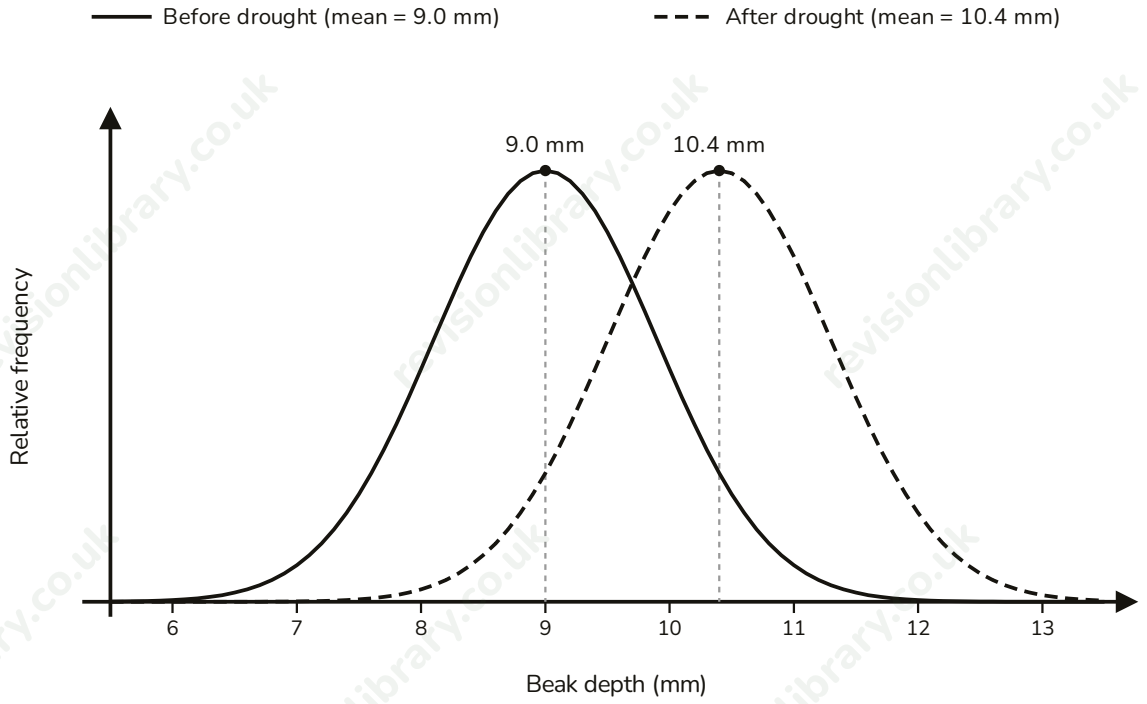
**(b)** A small group of 20 finches was blown off course by a storm and colonised a remote Atlantic island, founding a new population. Explain, using the term founder effect, why the allele frequencies in the new island population might differ significantly from the allele frequencies in the mainland population from which the finches came. **(3)**

**(c)** A population of 50000 elephant seals was reduced to just 30 individuals after a period of intense hunting in the 19th century, before recovering to over 200000 today. Explain why the genetic diversity of the modern population remains low despite its large size, using the term population bottleneck. **(3)**

**(Total for Question 4 is 7 marks)**


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**5** Ecologists studied the beak depth of a population of finches on a small island over several generations. Before a period of drought, beak depth followed a normal distribution with a mean of 9.0 mm. During the drought, only large, hard-shelled fruits were available, and finches with deeper, stronger beaks were better able to crack these open and survive. After the drought, the mean beak depth in the surviving population had increased to 10.4 mm, with the whole distribution shifted towards larger values.




**(a)** Identify the type of natural selection described. **(1)**

**(b)** Explain, with reference to the data, how directional selection produced this change in the finch population. **(3)**


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**(c)** A different island population of the same finch species experienced a change in food supply such that only very small, soft seeds and very large, hard seeds became available, with no intermediate-sized seeds. Predict and explain, using an appropriate named type of selection, how the distribution of beak depth in this population would change over several generations. **(3)**

**(Total for Question 5 is 7 marks)**

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**6** This question investigates the distribution and abundance of organisms, using the mark-release-recapture technique. Students estimated the population size of woodlice in a section of woodland. On the first day, they collected and marked 45 woodlice using a small dot of non-toxic paint, then released them back into the woodland. Two days later, they collected a second sample of 60 woodlice, of which 15 were found to be marked.

**(a)** State two assumptions that must be made for the mark-release-recapture method to give a valid population estimate. **(2)**

**(b)** Use the Lincoln index equation below to estimate the total population of woodlice in this section of woodland. **(3)**

Population estimate = (number caught in first sample x number caught in second sample) / number of marked individuals recaptured

**(c)** The paint used to mark the woodlice was bright orange. Explain how this might cause the population estimate calculated in part (b) to be inaccurate. **(2)**

**(Total for Question 6 is 7 marks)**


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# Mark scheme · 1.7 Genetics, Populations, Evolution and Ecosystems: 1-hour Pack

## Question 1

(a) NPP = 20000 - 8000 **M1**

(a) NPP = 12000 kJ $m^{-2}$ $yr^{-1}$ cao (correct units required) **A1**

**(a) Answer: 12000 kJ $m^{-2}$ $yr^{-1}$**

(b) (1200/12000) x 100 **M1**

(b) 10% cao **A1**

**(b) Answer: 10%**

(c) (150/1200) x 100 **M1**

(c) 12.5% cao **A1**

(c) transfer from primary consumers to secondary consumers (12.5%) was more efficient than from producers to primary consumers (10%) ft from candidate's values **B1**

**(c) Answer: 12.5%; the primary-to-secondary consumer transfer was more efficient than the producer-to-primary consumer transfer.**

(d) any one of: not all organisms/parts of organisms at a trophic level are eaten by the next level (e.g. roots, bones, uneaten material); not all ingested material is digested/absorbed, some is egested as faeces; much absorbed energy is lost as heat through respiration (and used for movement, excretion) rather than being converted to biomass **B1**

(d) any second, different point from the list above **B1**

**(d) Answer: For example: much energy is lost as heat through respiration, and not all biomass at one trophic level is eaten or fully digested by the next (any two valid reasons).**

## Question 2

(a) correct method, calculating $(n/N)^2$ for at least three of the five species **M1**

(a) sum[$(n/N)^2$] = 0.24 (awrt 2 dp) **M1**

(a) D = 1 - 0.24 = 0.76 (awrt) cao **A1**

**(a) Answer: D = 0.76 (awrt)**

(b) sum[$(n/N)^2$] = 0.81 (awrt 2 dp) **M1**

(b) D = 1 - 0.81 = 0.19 (awrt) cao **A1**

**(b) Answer: D = 0.19 (awrt)**

(c) Habitat A (woodland) has a much higher Simpson's Index (D approx 0.76) than Habitat B (wheat field, D approx 0.19), so Habitat A has much greater biodiversity ft from (a) and (b) **B1**

(c) Habitat B is dominated by a single species (wheat, 90% of individuals recorded), reducing evenness and therefore diversity oe **B1**

(c) this is because Habitat B is a managed monoculture (e.g. herbicides used to remove weed species and only one crop species deliberately planted), reducing the range and evenness of species present, whereas the woodland is unmanaged in this way oe **B1**

**(c) Answer: Habitat A has much higher biodiversity (D approx 0.76) than Habitat B (D approx 0.19), because Habitat B is a managed monoculture dominated by a single crop species, reducing species evenness and diversity.**

## Question 3

(a) p + q = 1 **B1**

(a) $p^2 + 2pq + q^2 = 1$ **B1**

**(a) Answer: p + q = 1 and $p^2 + 2pq + q^2 = 1$**

(b) $q^2 = 0.16$, so $q = \sqrt{0.16}$ **M1**

(b) q = 0.4 cao **A1**

**(b) Answer: q = 0.4**

(c) p = 1 - q = 0.6 ft from (b) **M1**

(c) 2pq = 2 x 0.6 x 0.4 = 0.48 **M1**

(c) number of carriers = 0.48 x 8500 = 4080 cao ft **A1**

**(c) Answer: 4080 people**

(d) any one of: no mutation occurs; the population is large (genetic drift is negligible); mating is random; no natural selection acts (no allele confers a survival/reproductive advantage); no gene flow/migration into or out of the population **B1**

(d) any second, different assumption from the list above **B1**

**(d) Answer: For example: no mutation occurs, and mating within the population is random (any two valid assumptions from the accepted list).**


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## Question 4

(a) the random change in allele frequency in a population from one generation to the next, due to chance rather than natural selection oe **B1**

**(a) Answer: Genetic drift is the random change in allele frequency in a population from generation to generation, due to chance.**

(b) the small founding group carries only a small, random sample of the alleles present in the mainland gene pool oe **B1**

(b) by chance this small sample may not be representative of the mainland allele frequencies (some alleles may be over-represented, under-represented, or absent) oe **B1**

(b) because the founding population is small, this chance effect (genetic drift/founder effect) has a proportionally larger effect on allele frequencies than it would in a large population oe **B1**

**(b) Answer: The founding population carries only a small, random sample of mainland alleles, which may not represent mainland frequencies; because the population is small, this chance effect has a large impact on allele frequencies.**

(c) only 30 individuals (and the alleles they carried) survived the population bottleneck, so much of the original genetic diversity/many alleles were lost by chance oe **B1**

(c) even though the population has since grown to over 200000, all these individuals are descended from the surviving 30, so alleles lost during the bottleneck cannot be regained (without new mutation) oe **B1**

(c) this reduces the gene pool/genetic diversity available for future natural selection, making the population more vulnerable to environmental change or disease oe **B1**

**(c) Answer: The bottleneck (30 survivors) lost much of the original allelic diversity by chance; the recovered population descends only from these survivors, so diversity remains low and the species is more vulnerable to future change.**

## Question 5

(a) directional selection **B1**

**(a) Answer: Directional selection**

(b) before the drought there was a range of variation in beak depth within the population, arising from mutation and new allele combinations produced by sexual reproduction oe **B1**

(b) during the drought, finches with deeper, stronger beaks were more likely to feed successfully on the large, hard-shelled fruits and survive; this differential survival raised the mean beak depth of survivors from 9.0 mm to 10.4 mm oe **B1**

(b) greater reproductive success of deeper-beaked survivors could pass alleles for greater beak depth to more offspring, increasing their frequency over subsequent generations oe **B1**

**(b) Answer: Existing heritable variation meant some finches had deeper, stronger beaks. These finches were more likely to feed successfully and survive the drought, raising the survivors' mean beak depth from 9.0 mm to 10.4 mm. Their greater reproductive success could increase the frequency of alleles for deeper beaks in subsequent generations.**

(c) disruptive selection (named) **B1**

(c) both extremes of the phenotypic range (small beak depth and large beak depth) are selected for, since these types can exploit the two available food sources oe **B1**

(c) individuals with intermediate beak depth are selected against (cannot efficiently use either food source), so the distribution becomes bimodal (two peaks) rather than a single normal distribution oe **B1**

**(c) Answer: Disruptive selection: both small- and large-beaked finches are favoured (each suited to one seed type), while intermediate beak depths are selected against, producing a bimodal distribution.**


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## Question 6

(a) any one of: no individuals die, are born, immigrate or emigrate between release and recapture; the marking method does not affect survival or behaviour (e.g. does not increase visibility to predators); the mark does not fade or rub off before recapture; marked individuals mix randomly/fully with the rest of the population before recapture **B1**

(a) any second, different assumption from the list above **B1**

**(a) Answer: For example: no individuals die, are born, or migrate into/out of the area during the study, and marked individuals mix randomly with the rest of the population before recapture (any two valid assumptions).**

(b) correct substitution: N = (45 x 60)/15 **M1**

(b) 45 x 60 = 2700 **M1**

(b) N = 2700/15 = 180 woodlice cao **A1**

**(b) Answer: 180 woodlice**

(c) bright paint may make marked woodlice more visible/conspicuous to predators, so more marked individuals may be predated (removed) before the second sample is taken oe **B1**

(c) this would reduce the number of marked individuals available to be recaptured, so the population estimate calculated would be an overestimate of the true population size oe **B1**

**(c) Answer: Bright paint may make marked woodlice easier for predators to spot, reducing the number of marked individuals surviving to recapture; this would make the calculated population estimate too high.**


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