17. Selection and Evolution

17.2 Natural and Artificial Selection

Paper 4

Marking Scheme

Q1.

(a)	*any **four** from:* **1** (random / spontaneous) mutation gave resistance ; **2** pathogen / disease / plague, was selection pressure ; **3** mutation, gave selective advantage / was selected for / allowed crayfish to survive (plague) ; **4** survivors / resistant crayfish, bred / reproduced / passed on mutation ; **5** frequency of, allele / mutation, (for resistance) increased ; **6** natural / directional, selection ; **7** AVP ;	**4**

Q2.

(a)(i)	as mutation rate increases lifespan decreases ;	**1**
(a)(ii)	*any **three** from:* **1** high(er) mutation rate gives more, genetic diversity / genetic variation / alleles / chance of beneficial allele ; **2** short(er) lifespan gives more generations (per year / per unit time) ; **3** with, high(er) mutation rate / short(er) lifespan, they, adapt / evolve, better / more easily / faster ; **4** mouse (and ferret) may, adapt / evolve, faster ; **5** AVP ;	**3**

(b)(i)	*comparison:* **C1** genetic engineering faster / selective breeding slower ; *any **one** reason from:* **R2** selective breeding occurs over (many) generations ; **R3** all cows could be surrogate mothers for engineered embryos (giving large increase in allele frequency in one generation) ; **R4** AVP ;	**2**

Q3.

(a)	*any **six** from:* 1 mutation / described ; 2 genetic drift / described ; 3 founder effect / group separated from main population to found a new population ; 4 bottleneck effect / large fall in population ; 5 natural / directional / disruptive, selection ; **Ignore** artificial / stabilising selection 6 migration / gene flow / interbreeding between populations ; 7 genetic recombination / linkage groups broken / crossing over ; 8 AVP ; e.g. effect larger in small populations	**6**
(b)	*any **three** from:* 1 inbreeding / described ; 2 produces homozygous plants / increases homozygosity ; 3 outbreeding / described ; 4 hybridisation / producing a hybrid ; 5 hybrids / offspring / F1, are (all) heterozygotes / have increased heterozygosity ;	**3**

Q4.

(a)(i)	*any **three** from:* **1** disruptive / diversifying (selection) ; **2** extremes / carnivores and detritus feeders, survive / are selected for **and** intermediates, die / are selected against ; **3** high / intense, competition ; **4** intermediates, outcompeted for / don't get enough, detritus / algae, and, (fairy) shrimp / small animals ; **5** lack of / limited, food is selection pressure ; **6** AVP ;	**3**

(a)(ii)	*any **three** from:* **1** stabilising (selection) ; **2** extremes / carnivores and detritus feeders, die / are selected against / are not selected for, **and** intermediates, survive / are selected for ; **3** low / less / prevents, competition ; **4** intermediates can eat, both types / all / a wider range, of food ; **5** greater variety in the diet improves the growth and development of (intermediate) tadpoles ;	**3**

Q5.

(b)	*any **five** from:* 1 (populations) can produce many offspring / AW ; 2 genetic variation occurs (in populations) / described ; 3 *ref.* mutations / sexual reproduction / gamete formation / random fertilisation ; 4 *ref.* competition qualified ; e.g. mates / food / resources 5 *ref.* selection pressure ; 6 some individuals have advantageous, adaptations / phenotype / traits / AW ; 7 (so) they, survive / reproduce / have a selective advantage ; 8 (so) pass on their advantageous allele(s) ; 9 (so) the (advantageous) allele frequency increases ;	**5**

Q6.

(a)(i)	$q^2 = 0.6$ **or** $q = \sqrt{0.6}$ **or** $q = 0.775$ **or** $p = 0.225$; $2pq = 2 \times 0.225 \times 0.775$ **or** 0.35 ; *allow ecf from mp1* 35 % ; *allow ecf from mp2*	**3**
(a)(ii)	*any **four** from:* 1 no migration **or** no flow of, alleles / genes, into / out of, the population ; 2 population is isolated / described ; e.g. separated by geographical barrier **I** *ref to* island alone 3 random mating is occurring ; 4 rats move around island / AW ; 5 large population ; 6 rats have high reproductive rate / no predators ; 7 rats are diploid ; 8 have two different alleles (for the gene) / heterozygous ;	**4**

(b)	*any **three** from:* 1 new allele initially found in heterozygotes ; *dominant advantageous allele* 2 (new) dominant allele is, expressed in heterozygote / always expressed ; 3 selection can act on individuals with dominant allele straight away / AW ; *recessive advantageous allele* 4 (new) recessive allele is not expressed, in heterozygote / due to dominant allele **or** recessive allele only expressed in homozygous recessive (genotype) ; 5 selection can only act on individuals who are homozygous recessive ; 6 it takes time for homozygous recessive (genotype) to occur / AW ;	**3**

Q7.

(a)(iii)	*any **three** from:* **1** cross / breed, rice / plants / individuals, with fast-growing stems ; **2** select / choose, and breed offspring with fast-growing stems ; **3** repeat (crossing **and** selection) over generations ; **4** hybridise / outbreed / out-cross **OR** avoid / reduce, inbreeding depression / background selection ;	**3**

Q8.

(a)	*any **five** from:* 1 select plants (resistant to disease) / AW ; 2 by exposing plants to disease to show resistance ; 3 breed (selected plants with resistance) ; 4 plant seeds / grow offspring ; 5 select offspring with resistance and breed together ; 6 (repeat for) many generations ; 7 AVP ; e.g. named wheat disease / rust disease / mildew disease	**5**
(b)	*any **two** from:* 1 reduction in genetic variation / gene pool made smaller / decrease in heterozygosity / increase in homozygosity ; **I** loss of biodiversity 2 less hybrid vigour ; 3 inbreeding depression ; 4 harmful recessive alleles could, come together / be expressed ; 5 (population) susceptible to, environmental change / new disease ; 6 AVP ; e.g. disadvantageous traits occur / reduced fertility / susceptible to metabolic disorders	**2**

Q9.

(a)	1 ($q^2 = \frac{440}{1100}$ **or** $q2 = 0.4$) $q = \sqrt{0.4}$ **or** $q = 0.632455532$; 2 ($p = 1 - 0.632455532$ **or** $p = 0.367544468$) $2pq = 2 \times 0.632455532 \times 0.367544468$ **or** $2pq = 0.4649110641$; 3 (heterozygotes = $2pq \times 1100$ e.g. 511.4 **or** 511.5 **or** 511.6672) 511 / 512 ;	**3**

Q10.

(d)(i)	*any **three** from:* 1 less able / not able, to, adapt / evolve ; 2 little variation for selection to act on ; 3 few(er) (potentially), useful / beneficial, alleles ; 4 all / most, (could be) killed by same, disease / selection pressure ; 5 if due to small population size this decreases species survival chance ;	**3**

Q11.

(a)(i)	*any **three** from:* 1 (random) mutation(s) allows detection of high frequency ; 2 selection pressure is bat (predation) ; 3 those that can detect, high frequencies / bats, survive / don't get eaten / have selective advantage / are selected for ; 4 these, reproduce / pass on (beneficial) allele(s) ; 5 those that can detect high sounds / beneficial alleles, increase (in frequency / in population) ;	**3**

Q12.

(a)	*any **four** from:* 1 breed / cross, plants with desired (named) characteristics ; 2 breed, better / best, offspring, repeatedly / for many generations ; 3 (*correct ref. to*) inbreeding / line breeding ; 4 (*correct ref. to*) hybridisation / outbreeding / outcrossing ; 5 (gives) hybrid vigour / heterosis / outbreeding enhancement (in offspring) ; 6 F1 have, same genotype / uniform phenotype ; 7 AVP ;	**4**
(b)(i)	*any **one** from:* 1 (IR8) less likely to, fall over / lodge / collapse ; 2 (IR8) higher proportion / more, of plant is, edible / grain ;	**1**
(b)(ii)	check for, genes / alleles / DNA, for high yield **and** flood tolerance ;	**1**
(b)(iii)	*any **one** from:* 1 to, maintain high yield / increase yield / give higher yield ; 2 to avoid inbreeding depression **or** to maintain, hybrid vigour / heterosis ;	**1**

Q13.

(a)(ii)	*any **one** from:* warning to predators / to deter predators ; AVP ;	**1**

Q14.

(b)(i)	*any **two** from:* **1** natural / selection ; **2** dark, colour / fur, selected for / adaptive / good, in woods / warm / shade ; **3** camouflage / right colour, protects against, (named) predators ;	**2**
(b)(ii)	*any **two** from:* **1** genetic drift / not natural selection ; **2** as small size in north not, adaptive / beneficial ; **3** (small) lose heat faster / harder to keep warm ; **4** smaller fat reserves not good with unstable food supply ; **5** less food in north reduces, growth / size ; **6** AVP ;	**2**
(c)	*any **three** from:* **1** (hybrid populations have) more, genetic variation / alleles ; **2** genes / mutations / alleles, from both (sub)species ; **3** more potential to adapt / can adapt better (in future) ; **4** genes / alleles, for migration may let some find new habitats ; **5** have, genes / alleles, for, warm and cold / different temperatures ;	**3**

Q15.

(b)	*any **three** from:* 1 not possible / difficult, to come to a (reliable) conclusion ; **A** AW 2 small difference in height / heights are similar (so natural selection **not** more important than genetic drift) ; 3 taller / lighter, bison could be an advantage in reaching higher vegetation (so natural selection **may** be important) ; 4 difference in mass, may not be due to genetic factors / may be due to nutrient value of diet / may be due to quantity of food, (so natural selection may **not** be important) ; 5 genetic drift (in ancestral population) may have led to, European bison being, taller / lighter **or** American bison being, shorter / heavier ;	**3**

Q16.

(c)	*any **four** from:* **1** humans apply selection pressure ; **2** select parents that show desired characteristic ; **R** gene / allele **3** breed these parents together ; **R** IVF **ignore** AI **4** select offspring with desired characteristics ; **5** breed selected offspring ; **6** repeating over many generations ; **7** AVP ; e.g. some outbreeding required to avoid, inbreeding depression / combining harmful recessive alleles	**4**

Q17.

(a)(i)	artificial selection ;	1
(a)(ii)	*any **five** from:* 1 (humans) choose / cross / breed from, females / cows / cattle, with, good / high, milk yield ; 2 (humans) choose / cross / breed from, males / bulls, with, mother / sisters / daughters, with, good / high, milk yield ; 3 (humans) choose / cross / breed from, desirable offspring ; 4 continue / repeat, for (several) generations ; 5 allele(s) for, high milk yield / desired trait, passed on ; 6 increase in frequency of, good / best / high yield, allele(s) ; 7 artificial insemination / A.I. ; 8 AVP ;	5
(b)	*any three from:* 1 mean / mode / median / average / intermediate, selected against / not favoured / less fit / die ; 2 (both) extremes, selected for / favoured / more fit / survive / reproduce ; 3 bimodal distribution ; 4 diversifying selection ; 5 causes / maintains, polymorphism / genetic diversity ;	3

Q18.

(c)	*any **five** from:* 1 human applies selection pressure / artificial selection ; 2 breed Saanen goat with, local / South African, goat ; 3 select offspring with, desired characteristics / high milk yield / adaptation to local conditions ; 4 breed offspring (with desired characteristics) ; 5 repeat (selection and breeding of offspring) for, several / many, generations ; 6 *ref. to* progeny testing / test milk yield in female offspring of male goats ; 7 avoid inbreeding / out-cross to unrelated goats ; 8 directional selection ; 9 AVP ; e.g. carry out programme in South Africa	5

Q19.

(c)(i)	*any **four** from:* 1 heterozygotes / Hb^A Hb^S / SCT / carriers, have, selective advantage ; 2 malaria is a selection pressure **or** homozygous dominant / Hb^A Hb^A, die of malaria ; 3 sickle cell anaemia is a selection pressure **or** homozygous recessive / Hb^S Hb^S, die of sickle cell anaemia ; 4 heterozygotes / Hb^A Hb^S / SCT / carriers, survive / reproduce ; 5 (so) passes on, Hb^S allele / sickle cell allele / mutant allele (to next generation) ; 6 stabilising selection ;	4

Q20.

(b)(i)	**CC** = (0.3 × 0.3 × 268 =) 24 ; **CG** = (2 × 0.3 × 0.7 × 268 =) 113 ;	**2**
(b)(ii)	chi-square(d test) / χ^2 ;	**1**
(b)(iii)	**1** **CC,** higher than predicted / 47 instead of 16 **or GG,** higher than predicted / 324 instead of 289 **or CG,** lower than predicted / 69 instead of 135 ; *plus any **two** from:* **2** could be (natural / artificial) selection against heterozygotes ; **3** could be (artificial) selection for, high milk yield / **CC** ; **4** migration / immigration / emigration ; **5** genetic drift ; **6** non-random mating ;	**3**

Q21.

(b)	*any **one** from:* 1 saltwater / ocean, fish had colonised the lake ; 2 *ref. to* protection from predators ; 3 mutation ;	**1**

(c)	*any **five** from:* 1 genetic variation (in population) ; 2 *ref. to* selective advantage / selection, for fewer armour plates ; **ora** 3 (so) could, grow larger / lay more eggs / shed more sperm **or** less energy wasted making armour ; **ora** 4 (they) survive / reproduce ; **ora** 5 pass on, advantageous / low armour, alleles (to offspring) ; **ora** 6 allele frequency of (low armour) increased ; **ora** 7 directional selection ; 8 *ref. to* low calcium supply ; 9 reduction in numbers of predatory fish ;	**5**

Q22.

(c)	*any **two** from:* 1 small gene pool / low genetic variation / low genetic diversity / low heterozygosity / high homozygosity ; 2 isolated (population) / described ; 3 inbreeding (within their population) ; 4 albinism has a selective advantage ; 5 founder effect / genetic bottleneck ; 6 genetic drift ;	**2**

Q23.

(a)(i)	(mean hind limb length) should decrease / legs get short**er** ;	**1**
(a)(ii)	(mean hind limb length) will vary ;	**1**
(b)	*any **five** from descriptions (**D**), suggestions (**S**) and explanations (**E**):* **D1** on, all / seven / the, experimental / founder, islands hind limb length decreased ; **S1** directional selection ; **D2** on source island hind limb length stayed the same ; **S2** stabilising selection ; *explanation in context of experimental islands:* **E1** selection pressure is, (reduced / thinner) perch / branch, (diameter); **E2** short (hind) limbs are, a selective advantage / selected for, on, experimental islands / founder islands / thin branches ; **E3** (short hind limbs) allow / increase, stability / survival ; **E4** (survivors), reproduce / breed / pass on allele(s) (for short hind limbs) ; **E5** allele(s) for short (hind) limbs increases in frequency ;	**5**

(d)	*any **three** from:* 1 (each island has a) small population ; 2 with, low genetic diversity / small gene pool ; 3 inbreeding depression / low heterozygosity / high homozygosity ; 4 environmental change / natural disaster, may, kill them all / make (whole / each) population extinct ;	**3**

Q24.

(a)	*any 4 of:* 1 spontaneous / random, mutation ; 2 produces an allele coding for enzyme (that gives resistance) ; 3 toxin is selection pressure ; 4 flies or larvae, with, allele / enzyme / mutation, have selective advantage ; 5 (flies with, allele / enzyme / mutation) survive / reproduce ; **ora** 6 pass on this allele (to offspring) ; 7 this allele increases in frequency ;	**4**

Q25.

(a)	*any four from:* 1 population / a species, show(s) genetic, variation / diversity ; 2 *ref. to* chance / random / spontaneous, mutation ; 3 *ref. to* selection pressure / competition / predation / disease ; 4 fitter / fittest OR better adapted / best adapted, (individuals) survive ; **ora** 5 reproduce / breed, more OR have more offspring ; **ora** 6 pass on, beneficial / advantageous / favourable / desirable, allele(s) ; **ora** 7 change / increase, in allele frequency ;	**4**
(b)(i)	*any two from:* normal distribution ; 5 is, usual / commonest / most frequent / peak, clutch size ; few(er) clutches, are very large and very small / are of size 2 and 8 / lie at (both) extremes ;	**2**
(b)(ii)	*any four from:* 1 stabilising selection ; 2 4 / 5 (eggs) **or** mean / average (clutch size), is optimum / better / best / selected for / has selective advantage / gives most (surviving) offspring ; 3 low clutch size / 2 / 3 , gives few(er) (surviving) offspring ; 4 high clutch size / 6 / 7 / 8 , not all offspring survive ; 5 high clutch size *linked to* more competition (between chicks) for, food / parental care ; 6 high clutch size *linked to* (more) predation (of eggs / chicks) ; 7 high clutch size *linked to* (more) disease (of eggs / chicks) ;	**4**

(c)(i)	*step 1:* 17 / 86 **or** 0.198 / 0.20 (q^2) ; *step 2:* √ 0.198 **or** 0.445 / 0.45 / 0.44 (q) **AND** 1 – 0.445 **or** 0.555 / 0.55 / 0.56 (p) ; *step 3:* 2 × 0.555 × 0.445 **or** 0.49(395) / 0.495 ($2pq$) **AND** 0.49(395) × 86 **or** 42 / 42.479 / 42.48 / 42.5 / 42.57 ;	**3**
(c)(ii)	*any two from:* 1 small population ; 2 (natural / artificial / sexual) selection ; 3 non-random mating / inbreeding ; 4 migration (of individuals) ; 5 (new) mutation (is occurring); 6 non-diploid organisms ; 7 overlapping generations ; 8 asexual reproduction ; 9 allele frequencies not equal in both sexes ;	**2**

Q26.

(b)	*any four from* **1** low / little / less / decreased (genetic) (bio)diversity / variation ; **2** low / little / less / decreased, heterozygosity ; **3** harmful recessive alleles may come together ; **4** inbreeding depression ; **5** no / less / decreased, hybrid vigour ; **6** not / less, able to adapt to, new / changed, selection pressure / disease / environment ;	**4**