1.11 Biology: Genetics, Populations and Evolution: Test Pack

Total Marks

AQA 7402 · Calculator allowed · about 40 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A population's gene pool is the complete set of alleles present in all the individuals of that population at a given time.

(a) Explain what is meant by the term gene pool. **(2)**

(b) Explain why genetic variation within a population's gene pool is essential for natural selection to bring about evolutionary change. **(3)**

(Total for Question 1 is 5 marks)

© Revision Library | revisionlibrary.co.uk

2 The human ABO blood group gene has three alleles: I^A and I^B, which are codominant with each other, and I^O, which is recessive to both. A father who is heterozygous for blood group A and a mother who is heterozygous for blood group B have children together.

(a) State the genotype of a person with blood group O. **(1)**

(b) Complete a genetic diagram for this cross and use it to determine the probability that a child of this couple has blood group O. **(3)**

(c) Explain what is meant by the term codominance, using the I^A and I^B alleles as your example. **(2)**

(d) Explain what is meant by the term multiple alleles, and explain why the ABO gene can have three alleles in the population's gene pool even though any one person can carry only two of them. **(2)**

(Total for Question 2 is 8 marks)

© Revision Library | revisionlibrary.co.uk

3 Evaluate the relative importance of natural selection and genetic drift in causing changes in allele frequencies within populations, and explain how the size of a population affects the balance between these two processes.

(Total for Question 3 is 6 marks)

---

4 In a breed of dog, coat colour is controlled by two genes on different chromosomes. Gene 1 has alleles B (black pigment, dominant) and b (brown pigment, recessive). Gene 2 has alleles E (allows pigment to be deposited in the coat, dominant) and e (prevents pigment being deposited, so the coat appears yellow regardless of genotype at gene 1, recessive). Two dogs that are both double heterozygotes (BbEe) are crossed.

(a) Define the term epistasis. **(2)**

(b) Complete a dihybrid genetic diagram for the cross BbEe x BbEe and determine the genotype ratio of the offspring, before considering the effect of epistasis. **(3)**

(c) Given that the ee genotype prevents pigment deposition regardless of the genotype at the B gene, state the phenotypic ratio of black : brown : yellow puppies expected from this cross. **(1)**

(d) Explain why the phenotypic ratio in part (c) differs from the standard 9:3:3:1 ratio usually expected from a dihybrid cross. **(2)**

(Total for Question 4 is 8 marks)

© Revision Library | revisionlibrary.co.uk

Mark scheme · 1.11 Biology: Genetics, Populations and Evolution: Test Pack

Question 1

(a) the gene pool is the complete range of alleles (of every gene) present in a population at a given time **B1**

(a) allele frequencies within it can be described as the proportion of each allele present **B1**

(a) Answer: The gene pool is the total collection of alleles (of all genes) present in the individuals of a population at a given time.

(b) mutation is the ultimate source of new alleles/new genetic variation within a gene pool **M1**

(b) if there is no variation in a heritable trait, all individuals have the same alleles/phenotype, so there can be no difference in survival or reproductive success between individuals **M1**

(b) without variation, allele frequencies cannot change over generations, so the population cannot adapt/evolve in response to a changing environment, increasing its risk of extinction **M1**

(b) Answer: Mutation is the ultimate source of genetic variation; without variation in a trait, no phenotype has an advantage over another, so natural selection cannot favour some individuals over others, allele frequencies cannot change, and the population cannot evolve to adapt to a changing environment.

Question 2

(a) $I^O I^O$ (or ii) oe **B1**

(a) Answer: $I^O I^O$

(b) correct gametes: father I^A, I^O; mother I^B, I^O **M1**

(b) correct offspring genotypes: $I^A I^B$, $I^A I^O$, $I^B I^O$, $I^O I^O$, each with probability 1/4 **M1**

(b) probability of blood group O = 1/4 cao **A1**

(b) Answer: 1/4 (25%)

(c) codominance is when two different alleles of a gene are both expressed in the phenotype of a heterozygote, with neither allele masking the other **B1**

(c) an individual with genotype $I^A I^B$ expresses both the A and B antigens on their red blood cells (blood group AB), rather than one allele masking the other **B1**

(c) Answer: Codominance means both alleles in a heterozygote are expressed in the phenotype; an $I^A I^B$ individual shows both A and B antigens (blood group AB) rather than one allele being masked.

(d) multiple alleles means more than two alleles of a gene exist within a population's gene pool, even though a diploid individual can carry only two of them at any one locus **B1**

(d) each allele arose from a separate mutation event (at different times/in different individuals), so the extra allelic variants can all persist and spread through the population's gene pool **B1**

(d) Answer: Multiple alleles means more than two versions of a gene exist across the whole population, even though each diploid individual can only carry two (one per homologous chromosome); the extra alleles arose from separate mutation events and can co-exist in the gene pool.

Question 3

Level 3 A clear, logically structured evaluation that explains how natural selection changes allele frequency through consistent, non-random differences in survival/reproduction linked to phenotype, and how genetic drift changes allele frequency through random chance, explicitly linking population size to the relative importance of each process, and reaches a reasoned overall conclusion. Appropriate scientific terminology is used accurately throughout. **5-6**

Level 2 A reasonably clear explanation of how both natural selection and genetic drift can change allele frequencies, with some attempt to link this to population size, but the comparison/evaluation is only partially developed or somewhat one-sided. **3-4**

Level 1 Basic, mostly descriptive statements about natural selection and/or genetic drift, with little or no reference to population size or comparison between the two processes. **1-2**

Level 0 No relevant content. **0**

Indicative content:

- Natural selection changes allele frequency because phenotypes with higher fitness survive/reproduce more successfully than others; it is a non-random, consistent process related to phenotype and the environment.
- Genetic drift changes allele frequency through random sampling of gametes/alleles between generations; it is unrelated to phenotype or fitness.
- In small populations, each generation is effectively a small sample of the gene pool, so random sampling error can cause large, unpredictable changes in allele frequency (drift is proportionally much stronger).
- In small populations, drift can cause harmful or neutral alleles to become fixed, and beneficial alleles to be lost, purely by chance, potentially overriding the direction selection would otherwise favour.
- Bottlenecks and founder events are examples of drift with especially large effects in small, isolated populations.
- In large populations, random sampling effects tend to average out across many individuals, so drift causes only small changes in allele frequency.
- In large populations, natural selection more reliably and consistently increases the frequency of advantageous alleles over generations, because chance fluctuations are relatively insignificant.
- Both processes can act simultaneously in any population; their relative importance depends on population size (and the strength of any selection pressure).
- A valid overall conclusion, e.g. genetic drift is most important in determining allele frequency change in small or isolated populations, while natural selection is the more dominant and predictable process in large populations.

© Revision Library | revisionlibrary.co.uk

Question 4

(a) epistasis is where the allele(s) of one gene mask(s) or affect(s) the expression of the allele(s) of a different gene (at a different locus) **B1**

(a) so the phenotype produced by one gene depends on the genotype at the other gene **B1**

(a) Answer: Epistasis is the interaction between genes at different loci, in which the allele(s) of one gene mask(s) or affect(s) the expression of the allele(s) of another gene.

(b) correct gametes from each parent: BE, Be, bE, be **M1**

(b) correct 4 x 4 Punnett square combination of gametes **M1**

(b) genotype ratio = 1 BBEE : 2 BBEe : 1 BBee : 2 BbEE : 4 BbEe : 2 Bbee : 1 bbEE : 2 bbEe : 1 bbee (accept an equivalent order with each genotype correctly identified) **A1**

(b) Answer: 1 BBEE : 2 BBEe : 1 BBee : 2 BbEE : 4 BbEe : 2 Bbee : 1 bbEE : 2 bbEe : 1 bbee

(c) 9 black : 3 brown : 4 yellow **B1**

(c) Answer: 9 black : 3 brown : 4 yellow

(d) the ee genotype is epistatic to the B gene, masking whichever pigment would otherwise be produced, so both B_{ee} and bbee puppies appear yellow **M1**

(d) this combines the B_{ee} (3) and bbee (1) classes into a single yellow phenotype class of 4, giving 9:3:4 instead of 9:3:3:1 **M1**

(d) Answer: Because ee is epistatic to the B gene, both B_{ee} and bbee genotypes (3 + 1 = 4 parts) appear yellow instead of forming two separate classes, merging two classes into one and changing the ratio from 9:3:3:1 to 9:3:4.

© Revision Library | revisionlibrary.co.uk