Year 11 Science: Variation in populations and gene tracking

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. A flock of 40 birds has 20 copies of allele b. What is the frequency of b?

2. Two unaffected parents have a child with a genetic condition. Is the allele for the condition dominant or recessive?

3. A flood kills most of a beetle population at random. Which population source is this, and what can happen to the allele frequencies?

4. Why were Richard Henry's chicks so valuable to Kākāpō Recovery, and which population source does this show?

5. In the PKU pedigree, what is the chance that individual 8 is a carrier, and how could it be confirmed?

Exam-style question: albino chicks in a sanctuary

Context: A predator-free island sanctuary breeds a rare flightless bird, all descended from a few founders. Albinism in this bird is caused by a recessive allele (a); the normal allele (A) is dominant. Male 5 was moved in from another island where no albino chick has ever been recorded.

6. Give the genotypes of birds 1, 2 and 3, and the possible genotypes of bird 4.

7. Explain why the genotype of bird 4 cannot be confirmed from the pedigree, and calculate the chance that she is a carrier.

8. The rangers plan to pair female 6 with her uncle, bird 3. Discuss this plan. Include the chance that a chick from the pair is albino (assume bird 5 is AA), why this is non-random mating, and how a DNA test for the a allele would change the decision. Evaluate how reliable your answer is.

Fix the mistake

9. Correct this statement: "Allele frequency of b = number of bb individuals ÷ population size."

10. Correct this statement: "An unaffected child of two carriers has a ¾ chance of being a carrier."

11. Correct this statement: "Non-random mating and inbreeding mean the same thing."

12. Correct this statement: "If a recessive allele becomes more common, more individuals will show the trait."

Answer key (for parents and tutors)

1. A flock of 40 birds has 20 copies of allele b. What is the frequency of b?
   40 birds have 80 alleles, so b = 20 ÷ 80 = 0.25.
2. Two unaffected parents have a child with a genetic condition. Is the allele for the condition dominant or recessive?
   Recessive: each parent must carry it without showing it.
3. A flood kills most of a beetle population at random. Which population source is this, and what can happen to the allele frequencies?
   Small population size (a bottleneck): allele frequencies change by chance (genetic drift), and rare alleles can be lost.
4. Why were Richard Henry's chicks so valuable to Kākāpō Recovery, and which population source does this show?
   He came from the mainland population, so his chicks carried alleles the Rakiura birds lacked, adding variation; this is like migration (gene flow).
5. In the PKU pedigree, what is the chance that individual 8 is a carrier, and how could it be confirmed?
   ⅔ (her parents 5 and 6 are both Pp and she is unaffected); a DNA test for the p allele would confirm it.
6. Give the genotypes of birds 1, 2 and 3, and the possible genotypes of bird 4.
   (Achieved) 3 is albino, so aa. 1 and 2 are unaffected but each passed an a to bird 3, so both are Aa. Bird 4 is unaffected, so AA or Aa.
7. Explain why the genotype of bird 4 cannot be confirmed from the pedigree, and calculate the chance that she is a carrier.
   (Merit) Aa × Aa gives 1 AA : 2 Aa : 1 aa. Bird 4 is not aa, so she is one of the three other boxes, and 2 of those 3 are Aa: a ⅔ chance she is a carrier. Her chicks 6 and 7 do not help: with an AA mate every chick is unaffected whether she is AA or Aa, so the pedigree cannot separate the two.
8. The rangers plan to pair female 6 with her uncle, bird 3. Discuss this plan. Include the chance that a chick from the pair is albino (assume bird 5 is AA), why this is non-random mating, and how a DNA test for the a allele would change the decision. Evaluate how reliable your answer is.
   (Excellence) Bird 6 is a carrier only if 4 is Aa (⅔) and passed on a (½): ⅔ × ½ = ⅓. Bird 3 is aa and always passes on a, so a chick is albino only if 6 is Aa and passes on a (½): ⅓ × ½ = ⅙, about 17%. Every chick from bird 3 also gets an a, so all the unaffected chicks are carriers, raising the frequency of a. Pairing relatives on purpose is non-random mating; in a small population it makes aa chicks, which are less likely to survive in the wild, more likely. A DNA test on bird 6 settles it: if she is AA, no chick will be albino (all will be Aa carriers); if she is Aa, each chick has a ½ chance. Pairing 6 with an unrelated AA male instead gives no albino chicks at all. The ⅙ depends on the assumption that bird 5 is AA; no recorded albino chicks on his island is not proof, and if 5 were Aa the risk would be higher. So the purpose of tracking, to keep the a allele from rising and avoid albino chicks, is best met by DNA testing 4, 5 and 6 before choosing pairs.
9. Correct this statement: "Allele frequency of b = number of bb individuals ÷ population size."
   Count copies of b: each Bb has one and each bb has two, then divide by twice the number of individuals.
10. Correct this statement: "An unaffected child of two carriers has a ¾ chance of being a carrier."
    Once we know the child is unaffected the aa box is ruled out, so it is 2 out of the remaining 3: ⅔.
11. Correct this statement: "Non-random mating and inbreeding mean the same thing."
    Inbreeding is one kind of non-random mating; choosing mates by a trait such as colour or size is non-random mating too.
12. Correct this statement: "If a recessive allele becomes more common, more individuals will show the trait."
    Not always: the extra copies can sit in carriers, where the dominant allele masks them, so the phenotype stays rare.