S6 Biology Practice Paper (Set 1) | Dihybrid cross and chi-square, Hardy-Weinberg, restriction digest, glomerular filtration, water potential, mark-recapture

S6 Biology | Time allowed: 75 minutes | Total: 100 marks | 24 questions

Section A: Dihybrid cross and chi-square test

Question 1 (17 marks)

1. In peas, round seed (R) is dominant to wrinkled (r) and yellow cotyledon (Y) is dominant to green (y). Two plants of genotype RrYy were crossed, giving 320 seeds: round yellow 178, round green 62, wrinkled yellow 58, wrinkled green 22. Assuming independent assortment, state the expected number of each phenotype. (4 marks)

2. Use a chi-square test to compare the observed and expected numbers. Write the chi-square formula and calculate the chi-square value (to 3 decimal places). (4 marks)

3. State the degrees of freedom. The critical value at $p = 0.05$ is 7.815. Decide whether to reject the hypothesis of independent assortment and state your conclusion. (4 marks)

4. One of the RrYy plants is test-crossed with an rr yy plant, producing 200 seeds. State the expected phenotypic ratio and the expected number of each class. (5 marks)

Section B: Hardy-Weinberg principle

Question 2 (17 marks)

5. Phenylketonuria, a recessive disorder, affects 1 in 10 000 people in a closed population. Assuming Hardy-Weinberg equilibrium, find the frequency of the recessive allele q. (4 marks)

6. Find the dominant allele frequency p and check that $p + q = 1$. (4 marks)

7. Find the carrier (heterozygote) genotype frequency $2pq$ and express it as a percentage. (4 marks)

8. If the population has 2 000 000 people, estimate the number of patients and carriers. Explain why the disease allele can persist in the population for a long time. (5 marks)

Section C: Restriction digest and gel electrophoresis

Question 3 (17 marks)

9. A linear DNA molecule is 8 000 bp long. EcoRI recognises two sites, 2 300 bp and 6 500 bp from the left end. State the lengths of the three fragments produced. (4 marks)

10. A plasmid is circular, 5 000 bp long, with a single EcoRI site. How many fragments are produced and what is the length? How does this differ from the linear DNA case? (4 marks)

11. A 1 200 bp insert is ligated into the 5 000 bp plasmid opened at its single site to form a recombinant plasmid. Calculate the total length of the recombinant plasmid. (4 marks)

12. In agarose gel electrophoresis, which of the three linear fragments (2 300, 4 200 and 1 500 bp) travels furthest? Explain why. (5 marks)

Section D: Glomerular filtration and clearance

Question 4 (17 marks)

13. A person has a glomerular filtration rate (GFR) of 125 mL/min and a filtration fraction (GFR divided by renal plasma flow) of 0.20. Calculate the renal plasma flow. (4 marks)

14. Calculate the volume of filtrate produced each day (in litres). (4 marks)

15. If 1.5 L of urine is excreted per day, find the volume reabsorbed by the renal tubules and the percentage reabsorbed (to 1 decimal place). (4 marks)

16. The clearance of inulin equals the GFR. If the haematocrit is 0.45, calculate the renal blood flow. Explain why most of the filtrate must be reabsorbed. (5 marks)

Section E: Water potential and plasmolysis

Question 5 (16 marks)

17. A plant cell has a solute potential of -800 kPa and a pressure potential (turgor) of 300 kPa. Calculate the water potential of the cell. (4 marks)

18. The surrounding soil has a water potential of -200 kPa. In which direction does water move? Explain. (4 marks)

19. When the cell is fully turgid its solute potential is -800 kPa and its pressure potential is 800 kPa. Calculate the water potential and state whether there is any net inflow of water when the cell is in pure water. (4 marks)

20. A plasmolysed cell has a pressure potential of 0 kPa and a solute potential of -900 kPa. Find its water potential. What happens if it is placed in pure water? (4 marks)

Section F: Mark-recapture and energy transfer

Question 6 (16 marks)

21. Researchers caught and marked 80 snails in a pond. After release, a second random sample of 120 snails contained 15 marked individuals. Estimate the population size using the Lincoln index. (4 marks)

22. State two assumptions on which this estimate depends. (4 marks)

23. Net production of the producers is 50 000 kJ m^-2 yr^-1. If the transfer efficiency between trophic levels is 10 percent, calculate the energy available to primary, secondary and tertiary consumers. (4 marks)

24. Explain where the other 90 percent of the energy goes, and why food chains usually have only four or five trophic levels. (4 marks)