S6 Biology Practice Paper (Paper 2)

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

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Part A Mendelian Genetics and the Chi-square Test (18 marks)

Assume independent assortment, no linkage and no lethal alleles. Give probabilities to 3 significant figures.

1. A cross Aa x Aa produces 800 offspring. Find the expected number showing (a) the dominant phenotype, (b) the recessive phenotype. (6 marks)

2. A test cross Aa x aa produces 400 offspring. Find the expected number of each phenotype. (4 marks)

3. A dihybrid cross AaBb x AaBb produces 1600 offspring. Using 9:3:3:1, find the expected number in each phenotypic class. (4 marks)

4. The observed numbers are 890, 310, 290 and 110. Calculate chi-square using chi2 = sum of (O-E)^2/E (3 significant figures) and decide whether the data fit 9:3:3:1 (critical value 7.815 at alpha = 0.05). (4 marks)

Part B Hardy-Weinberg Equilibrium (18 marks)

The population is in Hardy-Weinberg equilibrium, where q is the recessive allele frequency, p + q = 1 and the carrier frequency is 2pq.

5. The incidence of a recessive disorder is 1 in 10000. Find q, p and the carrier (heterozygote) frequency (3 significant figures). (6 marks)

6. If the carrier frequency is 1/25 (0.04), solve 2q(1 - q) = 0.04 for q (3 significant figures). (4 marks)

7. The population is 50,000. Find the number of affected individuals and carriers (nearest whole number). (4 marks)

8. If no affected individual reproduces, will q increase, decrease or stay the same after one generation? Explain. (4 marks)

Part C DNA, Gene Expression and Mutation (16 marks)

Each codon consists of 3 bases and codes for one amino acid; a stop codon codes for no amino acid.

9. The coding region of a gene is 3000 base pairs long and ends with one stop codon. Find (a) the number of codons in the mRNA, (b) the number of amino acids in the protein. (4 marks)

10. If the average amino acid has a mass of 110 Da, estimate the mass of the protein. (4 marks)

11. In a double-stranded DNA molecule, adenine (A) makes up 30% of all bases. Find the percentage of guanine (G). (4 marks)

12. A double-stranded DNA molecule has 1200 base pairs and A makes up 22%. Find the total number of G bases. (4 marks)

Part D Enzyme Kinetics (16 marks)

Use the Michaelis-Menten equation v = Vmax[S] / (Km + [S]); rates are in umol min^-1.

13. An enzyme has Vmax = 120 umol min^-1 and Km = 5 mM. Find the initial rate when [S] = 15 mM. (4 marks)

14. Find the rate when [S] = Km and state its kinetic significance. (4 marks)

15. Find the initial rate when [S] = 2 mM (3 significant figures). (4 marks)

16. A Lineweaver-Burk plot of 1/v against 1/[S] has slope 0.0417 min umol^-1 mM and y-intercept 0.00833 min umol^-1. Find Vmax and Km. (4 marks)

Part E Immunity and Vaccination (16 marks)

Herd immunity threshold = 1 - 1/R0; vaccine efficacy = (attack rate in unvaccinated - attack rate in vaccinated) / attack rate in unvaccinated x 100%.

17. A disease has R0 = 12. Find the percentage of the population that must be immune for herd immunity (one decimal place). (4 marks)

18. In a vaccine trial the attack rate was 8% in the unvaccinated group and 1% in the vaccinated group. Find the vaccine efficacy. (4 marks)

19. After vaccination a person has an antibody titre of 1:40. After 4 rounds of doubling, what is the final titre? (4 marks)

20. Give two reasons why the secondary immune response is faster and stronger than the primary response. (4 marks)

Part F Energy Flow in Ecosystems (16 marks)

Productivity is in kJ m^-2 yr^-1; ecological efficiency is the percentage of energy transferred between successive trophic levels.

21. An ecosystem has a gross primary production (GPP) of 45,000 kJ m^-2 yr^-1 and respiration of 20,000 kJ m^-2 yr^-1. Find the net primary production (NPP). (4 marks)

22. Primary consumers take in 10% of NPP. Find the energy assimilated by primary consumers. (4 marks)

23. In a food chain the net production of the tertiary consumer is 25 kJ m^-2 yr^-1 and each ecological efficiency is 10%. Find the net production of the primary consumer. (4 marks)

24. Give two reasons why food chains rarely have more than 5 trophic levels. (4 marks)
