S6 Biology Practice Paper (Set 2): Mendelian Inheritance and Probability, Gene Linkage and Genetic Mapping, DNA Structure and Semi-conservative Replication, Protein Synthesis and Frameshift Mutation, PCR and Genetic Engineering, Hardy-Weinberg Principle

S6 Biology | 100 marks | 75 minutes

Question 1: Mendelian Inheritance and Probability

In garden peas, the tall allele T is dominant to the dwarf allele t, and the round allele R is dominant to the wrinkled allele r. The two genes are located on different chromosome pairs.

State the genotypic and phenotypic ratios of the offspring from the cross Tt x Tt. *(3 marks)*

If the cross above produces 400 seeds that are all planted, how many dwarf plants are expected? *(4 marks)*

State the ratio of the four phenotypes in the offspring of the test cross TtRr x ttrr. *(5 marks)*

The cross TtRr x TtRr produces 480 plants. How many are expected to be tall round and how many dwarf wrinkled? *(6 marks)*

Question 2: Gene Linkage and Genetic Mapping

In fruit flies the body colour gene (A/a) and the wing shape gene (B/b) are on the same chromosome pair. A test cross of an AaBb individual with an aabb individual gives 800 offspring: AB 368, ab 352, Ab 40 and aB 40.

Identify the parental type offspring and their numbers. *(4 marks)*

Calculate the recombination frequency. *(4 marks)*

Find the map distance between the two genes. *(4 marks)*

If the AaBb individual produces 1,000 gametes, how many AB gametes are expected? *(4 marks)*

Question 3: DNA Structure and Semi-conservative Replication

A double-stranded DNA molecule has 1,000 base pairs, of which 600 are adenine (A).

Find the numbers of T, G and C. *(5 marks)*

Calculate the ratio (A + G) : (T + C) and state the reason. *(4 marks)*

How many free purine nucleotides are needed for one round of replication? *(5 marks)*

After three rounds of semi-conservative replication, what is the total number of DNA molecules and how many contain an original strand? *(4 marks)*

Question 4: Protein Synthesis and Frameshift Mutation

A mature mRNA has 900 bases, including one stop codon. Translation starts at the first codon.

How many codons does this mRNA contain? *(3 marks)*

How many amino acids are produced? *(4 marks)*

How many bases are on the DNA template strand that produced this mRNA? *(4 marks)*

If one base is deleted after the 200th codon, explain the effect on the protein produced. *(5 marks)*

Question 5: PCR and Genetic Engineering

The polymerase chain reaction (PCR) starts from one double-stranded DNA molecule and the target fragment doubles in every cycle.

How many copies are obtained after 20 cycles? *(4 marks)*

And after 30 cycles? *(4 marks)*

In gel electrophoresis of fragments of 200 bp, 600 bp and 1,800 bp, which migrates furthest and why? *(4 marks)*

A 6,000 bp plasmid is cut by a restriction enzyme into a 4,200 bp fragment and one other fragment. Find the length of the other fragment and explain towards which electrode DNA moves. *(4 marks)*

Question 6: The Hardy-Weinberg Principle

A population of 1,000 people contains 90 individuals showing the recessive trait (genotype aa). Assume the population is in Hardy-Weinberg equilibrium and the gene has only two alleles, A and a.

Find the frequency q of allele a. *(4 marks)*

Find the frequency p of allele A. *(4 marks)*

Find the number of carriers (Aa). *(4 marks)*

Find the number of individuals showing the dominant trait and write the formula used. *(4 marks)*