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JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

TEST -3 EXAMINATION- 2026

B.Tech-VIII Semester (BI)

COURSE CODE (CREDITS): 18B1WBI831 (3)

MAX. MARKS: 35

COURSE NAME: Computational Molecular Evolution

COURSE INSTRUCTORS: Dr. Tiratha Raj Singh

MAX. TIME: 2 Hours

*Note: (a) All questions are compulsory.**(b) The candidate is allowed to make Suitable numeric assumptions wherever required for solving problems**(c) Use of calculator is allowed*

Q.No	Question	CO	Marks
Q1	A pseudogene sequence from two species shows 24 nucleotide substitutions in a nonfunctional gene region of 1200-bp length. The neutral mutation rate is estimated to be 2×10^{-9} substitutions per site per year. Calculate the approximate time since the gene became nonfunctional.	4	3
Q2	Discuss the role of natural selection, mutation, recombination, and genetic drift in molecular evolution. Explain how molecular, fossil, embryological, and comparative genomic evidence support the gradual evolution of life on Earth. Illustrate your answer with modern examples from genomics and evolutionary biology.	3	4
Q3	Differentiate between the Codon Capture Theory and the Ambiguous Intermediate Theory of genetic code evolution. Discuss different classes of introns and explain the "Introns Early" and "Introns Late" hypotheses with suitable examples.	4	4
Q4	Discuss the "Recent African Origin" hypothesis and the "Multiregional Evolution" hypothesis for human evolution. Compare these hypotheses on the basis of: 1. Fossil evidence 2. Mitochondrial DNA analysis 3. Y-chromosome studies 4. Archaeological evidence 5. Genetic diversity patterns Which hypothesis is currently more accepted and why?	5	5
Q5	A gene consists of the following codons for Alanine: GCU, GCU, GCC, GCC, GCC, GCG From a reference set, the codon usage frequencies are: • GCU = 50% • GCC = 30% • GCG = 20%	5	4

	Calculate the Codon Adaptation Index (CAI) for the given gene. Explain the biological significance of CAI in gene expression studies.		
Q6	What is exon duplication and exon shuffling? Explain how exon rearrangements contribute to protein diversity and domain evolution. Discuss different mechanisms responsible for exon shuffling with suitable diagrams and examples.	4	4
Q7	Define synonymous and nonsynonymous substitutions. Explain the significance of K_a/K_s ratio in molecular evolution. Interpret the biological meaning of the following values: 1. $K_a/K_s > 1$ 2. $K_a/K_s = 1$ 3. $K_a/K_s < 1$ Support your answer with suitable biological examples.	5	4
Q8	What is the molecular clock hypothesis? If the neutral mutation rate per nucleotide per generation is 2×10^{-8} and the effective population size is 5×10^5 , calculate the expected number of neutral mutations fixed per generation according to Kimura's Neutral Theory.	4	4
Q9	Two homologous DNA sequences differ by 18 substitutions in a 300 bp region. If the mutation rate is 3×10^{-9} substitutions per site per year, estimate the divergence time between the two species.	3	3