Indian Association for the Cultivation of Science
(Deemed to be University under *de novo* Category)
Integrated Bachelor's-Master's Program
Mid-Semester (Sem-I) Examination-Autumn 2023

Subject: Molecules of life and cells ***Subject Code(s): BIS 1101***
Full Marks: 25 ***Time Allotted: 2 h***

Use separate pages for Part A and Part B
(Keep all subparts of a question together)

Part A: Answer all questions (25 marks)

1. (i) Which of the following can be used as microtubule-stabilizing and destabilizing drugs? **1**

(a) Nocodazole (b) Taxol (c) Cytochalasin (d) Phalloidin

(ii) What makes filopodia and stress fibers structurally similar but functionally different? **1**

(iii) True or false (give reasons): Microtubules determine the shape of the cell's surface and are necessary for whole-cell locomotion, and drive the pinching of one cell into two. **1**

(iv) Thermal force in pN on a protein per unit time due to head-on elastic collision from a water molecule with an average velocity of 600 m/s is **1**

(a) 18×10^{-12} (b) 24×10^{-12} (c) 30×10^{-12} (d) 36×10^{-12}

2. (i) The average time it takes molecules to move diffusively in the cytoplasm due to thermal forces by a distance of x cm is $t = x^2/2D$ where t is the time in seconds and D is the diffusion coefficient, which is a constant that depends on the size and shape of the molecule. **2**

How long would it take for a small molecule, a protein molecule, and a membrane-enclosed vesicle to diffuse across a cell 10 μm in diameter? A typical D for a small molecule is $5 \times 10^{-6} cm^2\ \mathrm{sec}^{-1}$, for a protein molecule $5 \times 10^{-7} cm^2\ \mathrm{sec}^{-1}$ and for a membrane-enclosed vesicle $5 \times 10^{-8} cm^2\ \mathrm{sec}^{-1}$.

(ii) Based on the results from (i), explain why a cell relies on the strategy of polymerizing and depolymerizing cytoskeletal filaments, rather than on the diffusion of filaments themselves, to accomplish its cytoskeletal rearrangements? **2**

3. (i) Schematically show the polymerization (subunit addition and removal) at the structurally/chemically inequivalent ends of a polymer with all possible rate constants. **1**

(ii) Consider a polymer with inequivalent ends having 4 rate constants (for +/- ends). **1**

(a) Write down the first-order differential equations to describe the growth rates at both ends at free monomeric concentration $[M]$ + 1

(b) What are the critical concentrations $[M]_c^+$ and $[M]_c^-$ at + and – ends respectively? + 1

(c) Graphically describe the rate of growth when the $[M]_c^+ = [M]_c^-$ and $[M]_c^- > [M]_c^+$ + 1

(d) As a special case of $[M]_c^- > [M]_c^+$ what special feature of the filament do you expect and why?

Part B: Answer all questions (25 marks)

4. Select each of the following that correctly describe the coding relationships (template → product) for replication, transcription, and translation? **1**

5. There are 21,000 protein-coding genes in the human genome. If you wanted to use a stretch of the DNA of each gene as a unique identification tag, roughly what minimum length of DNA sequence would you need? To be unique, the length of DNA in nucleotides would have to have a diversity (the number of different possible sequences) equivalent to at least 21,000 and would have to be present once in the haploid human genome (3.2 × 10 9 nucleotides). (Assume that A, T, C, and G are present in equal amounts in the human genome.) **2**

6. All naturally occurring α–amino acids (except glycine) are optically active due to the presence of chiral carbon atom. These have either D- or L-configuration. D-form means that, the amino (−NH2) group is present towards the right hand side. L-form shows the presence of (−NH2) group on the left hand side. Why do you suppose that only L-amino acids and not a random mixture of L- and D-amino acids are used to make proteins? **2**

7. You are returning from an abroad trip, you explain to the customs agent that you are bringing in a sample of DNA, deoxyribonucleic acid. He is worried that you want to bring an acid into his country. What is the acid in DNA? And what if any should the customs agent be worried about the DNA ? **1**

8. A segment of DNA from the interior of a single strand is shown in Figure1 . What is the polarity of this DNA from top to bottom? **1**

9. Look at the molecules in Figure 2. **3**

A. What would you expect to happen if dideoxycytidine triphosphate (ddCTP) were added to a DNA replication reaction in large excess over the concentration of deoxycytidine triphosphate (dCTP)? Would it be incorporated into the DNA? If it were, what would happen after that? Give your reasoning.
B. What would happen if ddCTP were added at 10% of the concentration of dCTP? C. What effects would you expect if dideoxycytidine monophosphate (ddCMP) were added to a DNA replication reaction in large excess, or at 10% of the concentration of dCTP?

10. True or false:

a) Both germ-cell DNA stability and somatic-cell DNA stability are essential for the survival of the species, explain. **1**

b) The tendency for an amino acid side-chain group such as –COOH to release a proton, its pK, is the same for the amino acid in solution and for the amino acid in a protein. **+ 1**

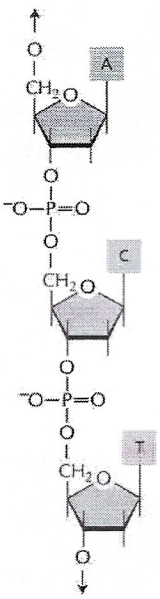

Figure-1

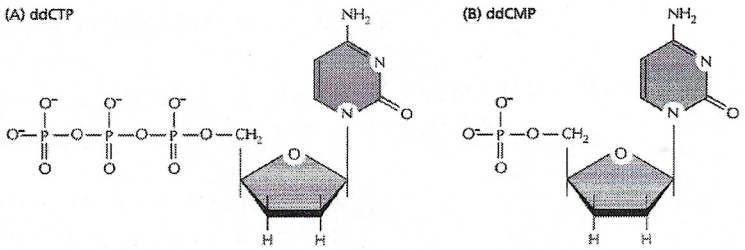

Figure-2