Indian Association for the Cultivation of Science

(Deemed to be University under the *de novo* category)

Integrated Bachelor's and Master's Program

End-Semester Examination - 2019 (Semester-I)

Subject: Molecules of Life and Cells ***Subject Code(s): BIS 1101***

Full marks: 100 ***Time allotted: 3 h***

(Answer PART - A and PART - B separately in your answer-script)

PART - A (Full marks 50)
Answer all questions

1. (a) What is cell cycle? Name the four basic phases of mitosis. [1+2]

   (b) What do actin filaments do? Why intermediate filaments are non-polar? [1+2]

   (c) What is Focal Adhesion? Draw a schematic diagram describing the structural organization of the focal adhesion. [1+2]

   (d) How would you distinguish between a free and a tethered protein molecule in solution by studying the microscopic trajectory of the protein. [3]

   (e) What is step length of a molecular motor? Explain the duty cycle. [1+2]

   (f) Consider a protein in a cytoplasm as a Voigt element comprises a spring and a dashpot in series. Describe how the protein will relax when released from a stretched configuration. [3]

   (g) Describe Fick's 2^{nd} equation. Use this equation to comment on the change of concentraion with time when spatial gradient is constant. [2+1]

2. (a) In biology, we often want to know the probability that a certain event will occur. For instance, an organism or animal in a given environment will either survive or die. Consider the probability that exactly k such events occur in n trials with probability p given by binomial distribution $P(k;n,p)=\binom{n}{k}\, p^k q^{n-k}$ where $\binom{n}{k} = \frac{n!}{k!(n-k)!}$. Find the mean and the standard deviation.

   (b) The Poisson distribution is a special case of the binomial distribution and is used to describe the distribution of rare events in a large population. Show that for a Poisson distribution, $\sum_{x=0}^{\infty} P(x) = 1$.

   (c) At the onset of an epidemic outbreak, find the probability of at most 5 diseased animals found in a flock of 200 animals, if experience shows that 2% of such animals are diseased.

   [(2+3)+2+3]

3. Evidence suggests that the hydrolysis of the GTP cap of a microtubule occurs at a rate constant k_{hydro} that is independent of monomer concentration and has units of $[time]^{-1}$, just like k_{off}. Let us evaluate the growth of the GTP cap for a specific tubulin concentration.

(a) Show that the number of tubulin dimers in the cap grows like $\frac{dn^+_{cap}}{dt} = \frac{dn^+}{dt} - k_{hydro}$, assuming that the monomer solution is pure GTP-tubulin.

(b) Calculate $\frac{dn^+}{dt}$ from Table given below if $[M] = 20\ \mu M$.

(c) Assume, without experimental justification, that $k_{hydro} = 30s^{-1}$. Plot the filament length, and the cap length, as a function of time until the filament reaches $10\mu M$ assuming that the negative end does not change with time (a tubulin dimer is about 8 nm long).

- units are $(\mu M \cdot sec)^{-1}$ for k_{on}, sec^{-1} for k_{off}, and μM for $[M]_c$

monomer in solution	k_{on}^+	k_{off}^+	k_{on}^-	k_{off}^-	$[M]_c^+$	$[M]_c^-$
	(plus end)		*(minus end)*			
microtubules						
growing (GTP)	8.9±0.3	44±14	4.3±0.3	23±9	4.9±1.6	5.3±2.1
rapid disassembly	0	733±23	0	915±72	not applicable	

[4+3+3]

4. For molecules and assemblies that move passively within the cell, the associated time scale can be estimated from features of diffusion.

(a) For a protein with a 5 nm diameter, compute the diffusion constant in water using Stokes-Einstein equation. Take k_BT= 4 pN.nm, viscosity of water 10^{-3} Pa.s.

(b) What is the time scale for a protein to diffuse within *E.coli*? The size of the *E.coli* is $\sim 1\ \mu$m.

(c) Find the diffusion time for the squid giant axon, which has a length of the order of 10 cm.

(d) Note down the key conclusion from the estimation of the above time scales and how it correlates with the activity of molecular motors.

[2+2+2+3]

PART - B (Full marks 50)
Answer all questions

5. **True of flase Explain (1+1 each, total marks 20)**

(a) In E. coli, where the replication fork travels at 500 nucleotide pairs per second, the DNA ahead of the fork must rotate at nearly 3000 revolutions per minute.

(b) Since introns are largely genetic "junk," they do not have to be removed precisely from the primary transcript during RNA splicing.

(c) Lipid bilayer is permeable to hydrophobic molecules

(d) Both the layers of the plasma membrane of the cells are composed of identical lipids.

(e) There exists a direct transport of molecule between mitochondria and the exterior of the cell

(f) Nuclear envelop is made up of TWO lipid bilayer

(g) Signal sequences are often found at the C terminal of the protein

(h) The translocation complex on ER can transport proteins to two distinct destination 1)across the membrane and 2) transfer it in the lipid bilayer

(i) Post-translational translocation require ATP hydolysis

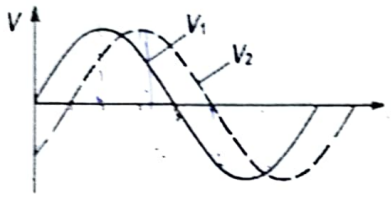
(j) Co-translational translocation require ATP hydolysis

6. **Write the correct choice (2 each, total marks 10)**

(a) Which of the following optical microscopy techniques have best z-resolution (smallest resolution)

A) Confocal B) Fluorescence microscopy C) TIRF D) Two photon imaging

(b) What is the phase difference between wave V1 and V2, in the following figure?



A) 45Deg B) 90Deg C) 135Deg D) 180Deg

(c) Which of the following will not modify the wave-front ?

A) Prism B) Concave lens C) Convex lens D) Rectangular Glass slab

(d) Which of the following improves the resolution (r) in optical imaging (small value of r)?

A) Increasing the wavelength of light B) Increasing the diameter of the lens
C) Increasing the size of the object D) increasing the refractive index of the object

(e) Which of the following improves the resolution (r) in confocal imaging?

A) decreasing the pin hole B) increasing the pin hole
C) increasing the gain of the detector D) increasing the laser paper

7. **Answer any 4 (5 marks each, total marks 20)**

(a) Describe the process of co-translational translocation in ER.

(b) During vesicular mode of protein sorting, How does the vesicle get enriched of cargo molecules?

(c) Compare the optical diagram of a bright field microscope with fluorescence microscope

(d) Describe the working of Phase contrast microscopy

(e) Describe the working of DIC microscopy

(f) Describe the working of Confocal microscope