

Indraprastha Institute of Information Technology Delhi (IIITD)
Department of Computational Biotechnology
BIO211 – Cell Biology and Biochemistry

End-Semester Exam (December 26, 2021)

Time duration: 1.5 hours (10:00-11:30 AM)

Total marks: 100

Instructions:

1. You are required to submit a single PDF file with all the properly labelled answers.
2. Add your roll number to the file name.
3. You will have 10 mins extra after 11:30 AM to compile and return your answer sheets.

Question 1. The equilibrium constant, K_{eq} for the following reaction $ATP \rightarrow ADP + P_i$ is 2×10^5 M. If the measured cellular concentrations at an instance of time are $[ATP] = 5\text{mM}$, $[ADP] = 0.5\text{mM}$, and $[P_i] = 5\text{mM}$, is the reaction at equilibrium in living cells? **[3 marks]**

Question 2. Calculate the approximate molecular weight of a protein with 345 amino acid residues in a single polypeptide chain? **[2 marks]**

Question 3. It has been observed that proteins with diverse amino acid sequences can have similar tertiary structures. Therefore, we say protein structures are more conserved than individual amino acid sequences. Comment on this statement. **[2 marks]**

Question 4. An enzyme has a V_{max} of $1.2 \mu\text{M/s}$. The K_m for its substrate is $15 \mu\text{M}$. Calculate the initial velocity, V_0 of the reaction catalyzed by this enzyme when the substrate concentration is $30 \mu\text{M}$. **[3 marks]**

Question 5. Differentiate between **any 3** of the following: **[6 marks]**

- (i) Active and passive transport
- (ii) Paracrine and autocrine signaling
- (iii) Heterochromatin and euchromatin
- (iv) Cohesins and condensins

Question 6. The DNA isolated from two newly identified bacterial species (AB and XY) was found to have 14% and 38% adenine respectively.

- (i) What relative proportional of adenine, guanine, thymine and cytosine are expected in these two DNA samples? What assumptions did you take into consideration for this answer? **[3 marks]**
- (ii) Which of these two bacterial species you think was most likely isolated from a hot water spring (82°C), and why? **[3 marks]**

Question 7. While working with cultured cells, the student released that the cells can uptake glucose only when the growth medium is supplemented with Na^+ , else the cells die even after having surplus glucose concentration in the culture medium? Suggest a possible explanation for this situation. [2 marks]

Question 8. Arrange the following events in order of their occurrence after a presynaptic neuron releases acetylcholine into the synaptic cleft. [2 marks]

- (i) Vesicles carrying the neurotransmitter fuse with the cell membrane.
- (ii) Ligand-gated Na^+ channels open, causing an influx of Na^+ ions.
- (iii) Voltage-gated Na^+ channels open in the axon.
- (iv) Membrane depolarization triggers voltage-gated Ca^{2+} channels to open.
- (v) Local membrane depolarization in the axon triggers an efflux of K^+ .

Question 9. The actual free energy of hydrolysis of ATP under intracellular conditions (ΔG) differs from the standard free-energy change ($\Delta G'^0$).

- (i) Calculate ΔG for the hydrolysis of ATP in human erythrocytes, given that the standard free energy of hydrolysis of ATP is -30.5 kJ/mol and the concentrations of ATP, ADP, and P_i are 2.25, 0.25, and 1.65 mM, respectively. Assume pH to be 7.0, temperature to be 37°C and gas constant, R to be 8.315 J/mol.K . [5 marks]
- (ii) What can you say about the amount of energy required to synthesize ATP under the same cellular conditions? [2 marks]

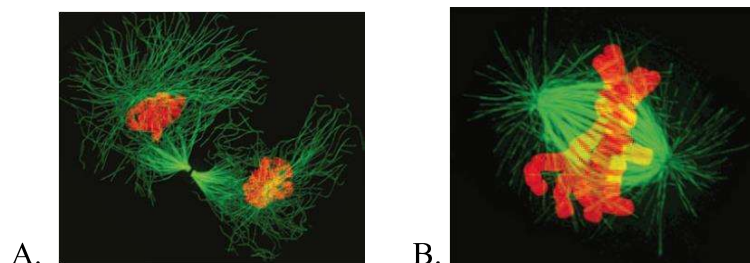
Question 10. Briefly discuss the three catabolic routes through which pyruvate formed by glycolysis is further metabolized. [6 marks]

OR

Answer the following:

- (i) Why phosphorylation of glycolytic intermediates considered important?
- (ii) Give the net equation of the overall glycolytic process.
- (iii) Give the three steps in glycolysis that strongly favor the direction of glucose breakdown making the process effectively irreversible.

Question 11. Identify the stage of cell division process shown in the given figures. List the characteristic features observed during these stages. [2 x 5 marks]



Question 12. State whether the given statement is TRUE or FALSE.

[10 marks]

- (i) The hereditary information of a cell is passed on by its proteins.
- (ii) Bacterial DNA is enclosed in a nucleus located in the cytosol.
- (iii) Hydrogen bonds are weak and can be broken by thermal energy, yet they contribute significantly to the specificity of interactions between macromolecules.
- (iv) The initiator tRNA enters the ribosome from E site.
- (v) Linking the reaction $X \rightarrow Y$ to a second, energetically favorable reaction $Y \rightarrow Z$ will shift the equilibrium constant of the first reaction.
- (vi) Okazaki fragments are removed by a nuclease that degrades RNA.
- (vii) Amino acids and lipids are amphipathic in nature.
- (viii) Lipids in a lipid bilayer do not flip-flop readily from one lipid monolayer to the other.
- (ix) Ubiquinone and cytochrome c are both diffusible electron carriers.
- (x) The enzymatic activity of a Cdk protein is determined both by the presence of a bound cyclin and by the phosphorylation state of the Cdk.

Question 13. What are the different components of replication machinery? Explain the function of each of these components.

[6 marks]

OR

Briefly describe the processing steps required to convert precursor mRNA to a matured mRNA. Also mention the cellular location for each of these processing steps.

Question 14. Show the rearrangement of Michaelis-Menten equation for Lineweaver-Burk representation. Draw a schematic of Lineweaver-Burk plot and mark the various parameters related to enzyme kinetics that can be estimated from the plot.

[4 marks]

Question 15. Explain the two factors that determine the fluidity of the lipid bilayer membrane?

[4 marks]

Question 16. What are the different functional classes of membrane proteins? Give an example of each.

[5 marks]

OR

What are the three ways in which an ion channel can be gated? Explain with the help of a diagram.

Question 17. Arrange the following in increasing rate of simple diffusion across the lipid bilayer membrane: Glucose, CO_2 , Na^+ , Water

[2 marks]

Question 18. Explain the two processes that segregate daughter chromosomes at anaphase.

[5 marks]

Question 19. Give an example in each of the following categories of extracellular signaling molecules:

[2 marks]

- (i) Hormone
- (ii) Local mediator
- (iii) Neurotransmitter
- (iv) Contact-dependent signaling molecule

Question 20. Describe the two major classes of intracellular signaling proteins that act as molecular switches. **[4 marks]**

Question 21. Match the following foreign substances to the normal cellular signal they relate to. **[3 marks]**

- | | |
|-----------------|----------------------------|
| A. Barbiturates | i. Cold |
| B. Morphine | ii. Acetylcholine |
| C. Menthol | iii. Glycine |
| D. Capsaicin | iv. Endorphin |
| E. Nicotine | v. Gamma-aminobutyric acid |
| F. Strychnine | vi. Heat |

Question 22. What are the three main transition points in the cell-cycle that are regulated by the cell-cycle control system? Mention one mechanism used by the control system to pause the cycle at each of these specific transition points. **[6 marks]**