V Semester

Paper No- 13: Biophysics Marks: 150

Biological phenomena cannot be understood fully without physical insight. Biophysics is an interdisciplinary frontier of science in which the principles and techniques of physics are applied to understand biological problems at every level, from atoms and molecules to cells, organisms and environment. The work always aims to find out how biological systems work. This paper covers various spectroscopic techniques, hydrodynamic methods, molecular biophysics and introduction to various physical principles responsible for maintaining the basic cellular function and integrity of biological membranes including transport across them.

THEORY **Total Lectures: 48**

Unit I: Biophysical techniques **(20 Lectures)**
(Chapter 3, 4 and 6: Sheehan; Chapter 14-17: Freifelder)

Basic principles of electromagnetic radiation: Energy, wavelength, wave numbers and frequency, review of electronic structure of molecules.
UV-visible spectrophotometry: Beer Lambert law, light absorption and its transmittance, factors affecting absorption properties of a chromophore, structural analyses of DNA/ protein using absorption of UV light.
Fluorescence spectroscopy: Theory of fluorescence, static and dynamic quenching, resonance energy transfer, fluorescent probes in the study of protein and nucleic acids.
Optical rotatory dispersion and Circular dichroism: Principle of ORD and CD, analysis of secondary structure of proteins (denatured and native form) and nucleic acids using CD.
Infra red spectroscopy: Theory of IR, identification of exchangeable hydrogen, number of hydrogen bonds, tautomeric forms.
Magnetic resonance spectroscopy: Basic theory of NMR, chemical shift, medical applications of NMR.
Mass spectrometry (MALDI-TOF): Physical basis and uses of MS in the analysis of proteins/ nucleic acids.
X-ray crystallography: Diffraction, Bragg's law and electron density maps (concept of R-factor and B-factor), growing of crystals (Hanging drop method).

Unit II: Hydrodynamic methods **(10 Lectures)**
(Chapter 7: Sheehan; Chapter11, 13: Freifelder)

Viscosity: Methods of measurement of viscosity, specific and intrinsic viscosity, relationship between viscosity and molecular weight, measurement of viscoelasticity of DNA.
Sedimentation: Physical basis of centrifugation, Svedberg equation, differential and density gradient centrifugation, preparative and analytical ultracentrifugation techniques, fractionation of cellular components using centrifugation with examples.
Flow Cytometry: Basic principle of flow cytometry and cell sorting, detection strategies in flow cytometry.

Unit III: Molecular biophysics **(10 Lectures)**
(Chapter 6: Sheehan; Chapter1: Freifelder; Chapter 2 and 3:Tinoco; Chapter 6: Watson)

Basic thermodynamics: Concept of entropy, enthalpy, free energy change, heat capacity.
Forces involved in biomolecular interactions with examples: Configuration versus conformation, Van der Waals interactions, electrostatic interactions, stacking interactions, hydrogen bond and hydrophobic effect.

Supercoiling of DNA: Linking number, twist and writhe.
Protein folding: Marginal stability of proteins, thermodynamic and kinetic basis of protein folding, protein folding problem (Levinthal's paradox), role of molecular chaperones in cellular protein folding, basics of molecular and chemical chaperones, protein misfolding and aggregation, diseases associated with protein misfolding.

Unit IV: Biological membranes **(08 Lectures)**
(Chapter 12: Hoppe)

Colloidal solution, Micelles, reverse micelles, bilayers, liposomes, phase transitions of lipids, transport of solutes and ions, Fick's laws of diffusion, ionophores, transport equation, membrane potential.

PRACTICALS

1. Effect of different solvents on UV absorption spectra of proteins.
2. Study of structural changes of proteins at different pH using UV spectrophotometry.
3. Study of structural changes of proteins at different temperature using UV spectrophotometry.
4. Determination of melting temperature of DNA.
5. Study the effect of temperature on the viscosity of a macromolecule (Protein/DNA).
6. Use of viscometry in the study of ligand binding to DNA/protein.
7. Crystallization of enzyme lysozyme using hanging drop method.
8. Analysis, identification and comparison of various spectra (UV, NMR, MS, IR) of simple organic compounds.

ESSENTIAL BOOKS

1. Physical Biochemistry: Principles and Applications, 2nd edition (2009), David Sheehan, JohnWiley.
2. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2nd edition (1982), David Freifelder, W.H. Freeman and Company.

3. Physical Chemistry: Principles and Applications in Biological Sciences, 4th edition (2001), I. Tinoco, K. Sauer, J.C. Wang and J.D. Puglisi, Prentice Hall.
4. Molecular Biology of the Gene, 7th edition (2007), Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R, Benjamin Cummings Publishers.
5. Biophysics, 1st edition (1983), W. Hoppe, W. Lohmann, H. Markl and H. Ziegler, Springer-Verlag.

SUGGESTED READINGS

1. The Physics of Proteins: An introduction to Biological Physics and Molecular Biophysics, 1st edition (2010), H. Frauenfelder, S.S. Chan and W.S. Chan, Springer.
2. Principles of Instrumental Analysis, 6th edition (2006), D.A. Skooget. al., Saunders College Publishing.
3. Principles of Physical Biochemistry, 2nd edition (2005), K.E. Van Holde, W.C. Jhonson and P. Shing Ho, Prentice Hall Inc.
4. Biophysical Chemistry, 1st edition (1980), C.R. Cantor, P.R. Schimmel, W.H. Freeman andCompany.
5. Crystallography Made Crystal Clear: Guide for Users of Macromolecular Models, 3rd edition (2010), Gale Rhodes, Academic Press.
6. Introduction to Protein Structure, 2nd edition (1999), C. Branden and J. Tooze, Garland Publishing.