DISCIPLINE SPECIFIC ELECTIVE COURSE-13 (BIOMED-DSE-13) PROTEIN STRUCTURE AND FUNCTION: ADVANCED CONCEPTS AND BIOMEDICAL APPLICATIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Protein Structure and Function: Advanced Concepts and Biomedical Applications	**4**	**2**	**-**	**2**	**Passes Class XII**	**Should have studied the basics of proteins.**

Learning Objectives:

The Learning Objectives of this course are as follows:

- This course is designed to deepen students' understanding the protein structure & function relationships and the remarkable protein folding processes.
- It also aims to help students understand enzyme kinetics and regulatory mechanisms, bridging the molecular intricacies of enzymology to the development of therapeutics and the underlying causes of diseases.
- The experiments have been designed for students to experience the molecular basis of protein biochemistry, connecting theoretical concepts to real-world biomedical challenges. By the end of the course, students will appreciate the fundamentals of protein biochemistry and its transformative applications in life science, industry and medicine.

Learning Outcomes:

Upon completing this course, students will:

- Understand the structural organization and key characteristics of proteins, their folding mechanisms, and the critical role of chaperons in achieving functional three-dimensional structures.
- Analyse protein misfolding and its association with various diseases.
- Comprehend enzyme function, regulation, kinetics and inhibition mechanisms, linking these concepts to developing therapeutic drugsand biomedical applications.
- Explore and appreciate the diverse applications of proteins and enzymes in pharmaceuticals, biomedicine, and industrial processes through theoretical insights and hands-on experience.

SYLLABUS

Unit I: Protein Structure and Functional Regulation: 10 Hours

Structure and function of proteins: membrane proteins (Aquaporin 1, ABC Transporter Protein), structural proteins (Keratin/ Collagen), DNA-binding regulatory proteins (Leucine Zipper motif/ Zn-Finger motif, with examples). Functional Allostery: limited proteolysis and ligand binding, with appropriate examples. Structural cooperativity (including oxygen saturation curves of hemoglobin and myoglobin). Post-translational modifications: phosphorylation (Protein Kinase A) and glycation. Domain swapping in proteins.

Unit II: Protein Folding: **6 Hours**

Introduction to Protein Folding: Levinthal Paradox, Anfinsen's Experiment, hydrophobic collapse. Functional and evolutionary significance of intrinsically disordered proteins. Molecular chaperones (structure and functional mechanisms of Hsp90, Hsp70, & Hsp40), Chaperonin (structure of GroEL-GroES system).

Unit III: Modern Techniques for Protein Characterization: 9 Hours

Manual protein sequencing (Edman Degradation, Sanger's Method), N-terminal and C-terminal analysis; Analysis of amino acid composition, Peptide mass fingerprinting (PMF), de-novo protein sequencing. Protein purification techniques: Isoelectric focusing (IEF), 2D-Gel electrophoresis and fast protein liquid chromatography (FPLC). Methods for determining protein stability (heat or chemical-induced denaturation).

Unit IV: Pharmaceutical & Industrial Applications of Proteins: **5 Hours**

Use of proteins in industry: protease, amylase and cellulase as detergents, pectinase and xylanase in fruit drinks, alkaline phosphatase and HRP in protein detection; Pharmaceutical applications: therapeutic proteins (thrombin/growth hormones, vaccines); Medical research: Abzymes, enzyme replacement therapy, diagnostic and prognostic biomarkers. Bioethics in protein research.

Practical: 60 Hours

(Wherever wet-lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs, etc.)

1. Salting out of proteins by Ammonium Sulphate Precipitation.
2. Desalting by dialysis.
3. Protein estimation by Bradford/BCA method
4. Tryptic digest of a given protein and analysis by SDS Polyacrylamide Gel Electrophoresis.
5. Protein estimation by using the molar extinction coefficient.
6. To study protein denaturation by urea and estimation of melting concentration (Cm).
7. Protein structure prediction using *in-silico* tools/approaches.
8. Project Practical: To visually score the changes in the structure of a protein due to mutations using Pymol or similar software. Examples: Mutation in Beta-globin gene in Sickle cell

anaemia and Cystic fibrosis transmembrane conductance regulator (CFTR) gene in cystic fibrosis. Similarly, more genes can be identified and analysed.

Essential Readings:

- Lehninger: Principles of Biochemistry (8th ed.). Nelson, D. L., & Cox, M. M. (2021). Macmillan. ISBN: 9781319322328.
- Biochemistry by Reginald H. Garrett, Charles M. Grisham; Ed. 6th; Cengage Learning, 2016.
- Biochemistry, by G., Stryer, L. and Tymoczko, JBerg, J., Gatto,. L. (2015) 8th Edition. New York, USA: W. H. Freeman and Company. ISBN-10 1464126100
- Fundamentals of Protein Stucture and Function, Buxbaum Engelberg; Ed. 6th; Springer, 2015.

Suggested Readings:

- Biochemistry by Mary K. Campbell, Shawn O. Farrell; Ed. 8th; Cengage Learning, 2014.
- Proteins: Structure and Function; David Whitford; John Wiley & Sons, 2013.
- Biochemistry by Donald Voet and Judith G. Voet; Ed. 4th; John Wiley & Sons, Incorporated, 2012.
- https://www.nobelprize.org/uploads/2024/10/advanced-chemistryprize2024.pdf
- Proteins: Structures and Molecular Properties by Thomas E Creighton; Ed. 3rd; Freeman, 2010.