Course title: Principles of Biochemistry and Biophysics			
Course code: BBP 154	**No. of credits: 2**	**L-T-P:** 28-0-0	**Learning hours:** 28
Pre-requisite course code and title (if any): Science graduate			
Department: Department of Biotechnology			
Course coordinator: Dr. Chaithanya Madhurantakam	**Course instructor**		
Contact details:			
Course type: Core	**Course offered in:** Semester 1		

Course description:

The course is designed to provide students with basic concepts, principles and applications of biochemistry and biophysics. This is aimed at providing information on molecular logic of life, supramolecular chemistry, structure and function of macromolecules, molecular circuits/ information processing cellular networks, cell mechanics and dynamics, molecular bioenergetics, and applications. The course will provide inputs on how emerging biochemical and biophysical techniques greatly enhanced our understanding of biological systems and functioning. Furthermore, the course is focused on recent developments and evolving scenarios in biochemistry and biophysics and will be a good platform for students to further pursue their careers in sciences.

Course objectives:

1. Introduction to the molecular components of a cell, complex chemistry, and their interactions with the environment.
2. Familiarization of students with the macromolecular structural organization and relation to the functional significance of such a conformation through enzyme kinetics.
3. Acquainting the students with concepts of cell mechanics and applications, cellular dynamics and techniques employed.
4. Familiarization with biomolecular interplay involved in signal transduction and ubiquitination, apoptosis, transport mechanisms and metabolic pathways.
5. Providing students with fundamentals of laws of thermodynamics, Non equilibrium thermodynamics and cellular bioenergetics.

Course contents

Module	Topic	L	T	P
Module 1: Biomolecules and supramolecular chemistry				
1.1	Biomolecules, Bioactive compounds and Molecular Environment, Supra-molecular Chemistry of Biomolecules (Specific and Non-specific Molecular, Interactions, Short range Repulsions, Electrostatic Interactions, Dipolar, Interactions, Fluctuating Dipoles, Hydrogen Bonding, Cation-π Interactions, Hydrophobic Effect, Counter-ion Release)	4	0	0
Module 2: Structure and function of macromolecules				
2.1	Levels of Structural Organization & Conformation, DNA structure, Protein structure, DSSP Classification, Ramachandran's Plot, Protein Folding & Misfolding, Structural Proteins & Regulatory Proteins, Enzyme catalysis and kinetics	4	0	0
Module 3: Cell mechanics and dynamics				
3.1	**Fundamentals in cell mechanics** Bio-membranes (Structure, Activity, Fluidity, Permeability and Dynamics), Membrane Channels, Ion pumps & Transporters, Membrane Potential, Diffusion coefficient, association and Brownian	4	0	0

	motion in biological systems			
3.2	**Cytoskeleton dynamics, models, and techniques** Force generation by cellular polymers, Power stroke and Brownian ratchet models of molecular motors, Helix-Coil transition model (DNA and Protein), Reynolds Number, Fluorescence Correlation Spectroscopy, Patch Clamps (electrophysiology), Cytological Optical Tweezers	6	0	0
Module 4: Molecular circuits and signaling				
4.1	Signal Transduction Cascades, Primary and Secondary Messengers, EGF Signalling and Receptor Tyrosine Kinases the Ras-MAPK pathway, Wnt Signalling, Apoptosis, Ubiquitin System, Metabolic Pathways of Macromolecules and Cellular Respiration	4	0	0
Module 5: Thermodynamics in biosystems				
5.1	The Laws of Thermodynamics, Gibbs free energy and Free energy changes, Redox Potentials and energy currency, The Three Levels of Bioenergetics in Eukaryotes/ Energy Transfer within Biosphere, Non-Equilibrium Thermodynamics (NET)	3	0	0
5.2	Thermogenesis, Uncoupling Protein Thermogenin and Mitochondrial Thermogenesis, Chloroplast Bioenergetics	3	0	0
	Total	**28**	**0**	**0**

Evaluation criteria:

4. Test 1 30%
5. Test 2 30%
6. Test 3 (end semester) 40%

Learning outcomes:

1. An understanding of the basic components and chemistry involved in cell survival (Tests 1, 2 & 3)
2. An insight into macromolecular organization and its structural as well as functional importance (Test 1 & 2).
3. The ability to apprehend the concepts of cell dynamics and techniques employed to study cell mechanics (Test 2).
4. A detailed analysis of various signalling mechanisms vital for living systems. Grasp of molecular networks and their interplay (Test 3).
5. The ability to understand molecular bioenergetics and apply the energy transformation mechanisms and laws governing the transformations (Test 3).

Pedagogical Approach:

1. Online/Offline teaching.
2. Providing case studies to support the concepts.
3. Peer-reviewed research articles to discuss various modules in the course.

Skill Set:

4. Analytical skills based on case studies provided.
5. Knowledge of macromolecular applications in various sectors.
6. Knowledge of techniques employed to understand cellular systems.

Employability:

The course will provide skillsets and knowledge that may play key role to get employed in Universities, R & D industry, Medical centres/Colleges, Research Institutes and Diagnostic centres apart from specialized units like pharma, breweries, dairy and agri sectors.

Materials:

Suggested Readings

1. Delbianco M, Bharate P, Varela-Aramburu S, Seeberger PH. Carbohydrates in Supramolecular Chemistry. Chem Rev. 2016 Feb 24;116(4):1693-752. doi: 10.1021/acs.chemrev.5b00516. Epub 2015 Dec 24. PMID: 26702928.
2. RAMACHANDRAN GN, RAMAKRISHNAN C, SASISEKHARAN V. Stereochemistry of polypeptide chain configurations. J Mol Biol. 1963 Jul;7:95-9. doi: 10.1016/s0022-2836(63)80023-6. PMID: 13990617.
3. Dobson CM. Protein folding and misfolding. Nature. 2003 Dec 18;426(6968):884-90. doi: 10.1038/nature02261. PMID: 14685248.
4. Chiti F, Dobson CM. Protein Misfolding, Amyloid Formation, and Human Disease: A Summary of Progress Over the Last Decade. Annu Rev Biochem. 2017 Jun 20;86:27-68. doi: 10.1146/annurev-biochem-061516-045115. Epub 2017 May 12. PMID: 28498720.
5. Kabsch W, Sander C. Dictionary of protein secondary structure: pattern recognition of hydrogen-bonded and geometrical features. Biopolymers. 1983 Dec;22(12):2577-637. doi: 10.1002/bip.360221211. PMID: 6667333.
6. Michaelis L, Menten ML, Johnson KA, Goody RS. The original Michaelis constant: translation of the 1913 Michaelis-Menten paper. Biochemistry. 2011 Oct 4;50(39):8264-9. doi: 10.1021/bi201284u. Epub 2011 Sep 9. PMID: 21888353; PMCID: PMC3381512.
7. Ait-Haddou R, Herzog W. Brownian ratchet models of molecular motors. Cell Biochem Biophys. 2003;38(2):191-214. doi: 10.1385/CBB:38:2:191. PMID: 12777714.
8. Mereghetti, P., Kokh, D., McCammon, J.A. *et al.* Diffusion and association processes in biological systems: theory, computation and experiment. *BMC Biophys* **4,** 2 (2011). https://doi.org/10.1186/2046-1682-4-2
9. Lamparter L, Galic M. Cellular Membranes, a Versatile Adaptive Composite Material. Front Cell Dev Biol. 2020 Aug 5;8:684. doi: 10.3389/fcell.2020.00684. PMID: 32850810; PMCID: PMC7419611.
10. Strasser A, O'Connor L, Dixit VM. Apoptosis signaling. Annu Rev Biochem. 2000;69:217-45. doi: 10.1146/annurev.biochem.69.1.217. PMID: 10966458.
11. Wallace DC. Colloquium paper: bioenergetics, the origins of complexity, and the ascent of man. *Proc Natl Acad Sci U S A*. 2010;107 Suppl 2(Suppl 2):8947-8953. doi:10.1073/pnas.0914635107
12. Biochemistry, 4th Edition, Donald Voet, Judith G. Voet, ISBN: 978-0-470-57095-1.
13. Biophysical Chemistry, Vol I, II & III by Charles R. Canter and Paul R. Shimmel. (A classic textbook)
14. The Biophysical Chemistry of Nucleic Acids and Proteins: Thomas E. Creighton;,Helvetian Press; 2010.

Additional information (if any): Not Applicable

Student responsibilities:

4. Study of course material as specified by the instructor.

Course reviewers:

1. Prof. Gourinath Samudrala, School of Life Sciences, Jawaharlal Nehru University (JNU), New Delhi- 110067
   E-mail: sgourinath@mail.jnu.ac.in

2. Dr. Vivekanad V, Ramalingaswami Fellow, Malaviya National Institute of Technology (MNIT), Jaipur, Rajasthan - 302017
   E-mail: vivekanand.cee@mnit.ac.in