UNIVERSITY OF DELHI

MASTER OF SCIENCE (BIOPHYSICS AND BIOINFORMATICS)

based on

NEP-PGCF-2024

As approved in the meeting of 'Committee of Courses' held on 24-Feb-2025& 03-Mar-2025, in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on 17-Mar-2025, and in the meeting of 'Standing Committee' held on _____

PROGRAMME BROCHURE

XXXXX Revised Syllabus as approved by Academic Council on XXXX, 2025 and Executive Council on YYYY, 2025

I. About the Department

Department Highlights

The Department of Biophysics was established in 1984 and is part of the FIAS (Faculty of Interdisciplinary and Applied Sciences) at the University of Delhi South Campus. The department currently has five faculty members engaged in various research areas in Biophysics and Bioinformatics.

About the Program

The M.Sc. Biophysics and Bioinformatics program offered by Delhi University is of two years' duration and is divided into four semesters. The various courses of the program are designed to include classroom teaching and lectures, hands-on practicals and tutorials, dry and wet laboratory work, and dissertations.

Six categories of courses are being offered in this program: Discipline Specific Core Courses (DSC), Discipline Specific Elective Courses (DSE), Generic Elective Courses (GE), Skill Based courses (SB), Research methods/ tools/ writing courses under Research Track (RT), and Dissertation Research work. Students may opt for any Generic Elective courses offered by any other Department of the Faculty of Interdisciplinary and Applied Sciences. The Core Courses, the Elective Courses and Generic Electives are four credit courses each. As per the University guidelines, the student is required to accumulate twenty-two credits each semester, a total of eighty-eight credits, to fulfill the requirements for a Master of Science (PG) degree in Biophysics and Bioinformatics.

The M.Sc. in Biophysics and Bioinformatics is an interdisciplinary program designed to bridge the gap between biology, physics, and computational sciences. The course integrates biophysical principles, molecular biology, computational biology, and bioinformatics to generate, interpret, and analyze large-scale biological datasets. The curriculum integrates theoretical knowledge with practical skills to train students in modern biophysics and bioinformatics, making them competent for careers in academia, healthcare, pharmaceuticals, and biotechnology industries.

Program Objectives (POs):

The program aims at equipping the students with advanced knowledge and skills in the area of biophysics and bioinformatics, such as to enable them to address present lacunae in biological systems understanding, with the following detailed objectives:

1. Foundational Knowledge in Biophysics & Bioinformatics

- Introduce students to fundamental principles of biophysics, molecular biology, bioinformatics, and computational biology.
- Provide a strong foundation in chemical, physical, and mathematical principles underlying biological processes.
- Equip students with knowledge of macromolecular interactions, protein structure, and cellular mechanisms.

2. Skill Development in Experimental and Computational Techniques

- Train students in molecular biology, genetic engineering, proteomics, and bioinformatics methodologies.
- Develop proficiency in computational biology tools, bioinformatics databases, and molecular modeling.
- Provide hands-on experience in biophysical techniques like spectroscopy, chromatography, and electrophoresis.
- Familiarize students with cell culture techniques and proteomics-based analytical methods.
- Equip students with knowledge of gene regulation, genetic engineering, and genome editing technologies (e.g., CRISPR, TALENs).
- Develop skills in protein-protein interactions, and vaccine development.

3. Application of Biophysics and Bioinformatics in Research and Industry

- Enhance understanding of drug discovery, protein engineering, and genetic manipulation.
- Introduce applications of biophysics in disease modeling, structural biology, and vaccine development.
- Enable students to apply bioinformatics in genome sequencing, phylogenetic analysis, and personalized medicine.

4. Critical Thinking and Problem-Solving

- Encourage students to analyze and interpret biological data using statistical and computational approaches.
- Train students to design experiments for biomolecular research, drug development, and biomedical engineering.
- Develop skills in scientific communication, literature review, and data presentation.

5. Preparing for Advanced Research and Careers in Biotechnology & Healthcare

- Prepare students for careers in biotechnology, pharmaceuticals, computational biology, and academic research.
- Equip students with knowledge of current trends in biotherapeutics, vaccines, and bioenergetics.
- Provide exposure to ethical considerations, regulatory guidelines, and real-world applications in biosciences.

6. Genetic and Structural Insights into Biological Systems:

- Equip students with knowledge of gene regulation, genetic engineering, and genome editing technologies (e.g., CRISPR, TALENs).

- Develop skills in protein-protein interactions, drug discovery, and vaccine development.

7. Application of Biophysical and Bioinformatics Approaches:
   - Bridge the gap between wet-lab experiments and computational biology.
   - Enable the integration of machine learning and AI-driven approaches for analyzing biological datasets.

Program Specific Outcomes (PSOs):

Upon successful completion of the M.Sc. in Biophysics and Bioinformatics, graduates will be well-equipped to contribute to the biotechnology and biological data analysis industries in the following areas:

1. Biotechnology Industry Contributions
   - Drug Discovery & Development:
     - Apply computational modeling for drug design and screening.
     - Analyze protein-ligand interactions for pharmaceutical applications.
   - Genetic Engineering & Synthetic Biology:
     - Utilize CRISPR, gene editing, and molecular cloning for therapeutic and agricultural advancements.
     - Engineer microbial and plant-based biofactories for biopharmaceuticals and industrial enzymes.
   - Bioprocessing & Biomanufacturing:
     - Apply protein purification, expression optimization, and bioanalytical techniques in biopharmaceutical production.
     - Optimize fermentation and metabolic pathways using computational tools.
   - Vaccine & Biotherapeutic Development:
     - Design rational vaccines and immunotherapies.
     - Conduct immune response modeling for personalized medicine.

2. Biological Data Science and Analysis
   - Big Data Analytics in Life Sciences:
     - Analyze high-throughput genomic, transcriptomic, and proteomic datasets.
     - Use machine learning and AI for predictive modeling in personalized medicine.
   - Computational Biology & Bioinformatics Tools:
     - Perform sequence alignment, phylogenetics, and structural modeling.
     - Develop and use databases for genomic and proteomic research.
   - Systems Biology & Omics Data Integration:
     - Model biological networks for understanding disease mechanisms.
     - Integrate multi-omics data (genomics, transcriptomics, proteomics) for biomarker discovery.
   - Statistical & Programming Skills for Biological Data Analysis:
     - Use R, Python, and bioinformatics pipelines for statistical inference.
     - Apply machine learning algorithms to classify biological patterns and anomalies.

About Program Structure

The M.Sc. Biophysics and Bioinformatics program is divided into four semesters. The program structure is based on the Post Graduate Curricular Framework (PGCF) under (New Education Policy) NEP-2020.
The student is required to complete eighty-eight credits for the completion of the course and the award of a degree. The student has to accumulate twenty-two credits in each of the four semesters.
Under PGCF, during the first year of the program, the student is required to study mandatory six Discipline Specific Core courses (three DSC in each semester), and a total of four Discipline Specific Elective courses (two DSE in each semester). The student can also opt for 1GE from another sister department from FIAS instead, thus making this combination as 1DSE+1GE. In addition, the student will also be required to study 1 mandatory Skill based course (SBC) of 2 credits in each semester of the first year.

In the second year of the program, the student will choose any one of the three structures: Program Structure 1 (PG with only coursework), or Program Structure 2 (PG with coursework and research), or Program Structure 3 (PG with research) as per the university guidelines. The details of the course credits and the courses available under each category of courses (DSC, DSE, GE, SB, RT) are elaborated in the tables ahead.

A minimum of 75% attendance in the practical and theory classes would be mandatory requirement for appearing in exams and obtaining the degree.

Course Credit Scheme

Program Structure-1: (PG with only coursework)

Sem	*Core courses (DSC)*		*Elective courses (DSE/GE)*		*Skill based courses (SB)*		*Res Track courses (RT)*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	3	12	1	2	-	-	-	-	22
IV	2	8	3	12	1	2	-	-	-	-	22
Total Credits	**40**		**40**		**8**		**-**		**-**		**88**

Program Structure-2: (PG with coursework + research)

Sem	*Core courses (DSC)*		*Elective courses (DSE/GE)*		*Skill based courses (SB)*		*Res Track courses (RT)*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	2	8	-	-	-	-	1	6	22
IV	2	8	2	8	-	-	-	-	1	6	22
Total Credits	**40**		**32**		**4**		**-**		**12**		**88**

Program Structure-3: (PG with research)

Sem	*Core courses (DSC)*		*Elective courses (DSE/GE)*		*Skill based courses (SB)*		*Res Track courses (RT)*		*Dissertation/ Project*		*Total Credits*
	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	No. of Courses	Total Credit	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	1	4	1	4	-	-	2	4	1	10	22
IV	-	-	1	4	-	-	1	2	1	16	22
Total Credits	**28**		**24**		**4**		**6**		**26**		**88**

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. BIOPHYSICS AND BIOINFORMATICS COURSE (NEP-PGCF)

First year (Common in Program Structure 1, 2 and 3)

Semester-1

	Credits in each course			
	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC01: Biophysical Chemistry	3	0	1	4
BP-DSC02: Molecular Biology	3	0	1	4
BP-DSC03: Protein Sciences: Emerging Frontiers	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE01: Cellular Proteomics	3	1	0	4
BP-DSE02: Statistics and Programming for Life Sciences	3	0	1	4
BP-DSE03: Vaccines and Biotherapeutics	3	0	1	4
Generic Elective courses*				
#BP-DSE01: Cellular Proteomics	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
BP-SBC01: Specialised Laboratory – I: Molecular Biology	0	0	2	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

***** *(a student can opt for either two DSE course, or one DSE with one GE)*

#BP-DSE01 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

SEMESTER-WISE PROGRAM STRUCTURE of M.Sc. BIOPHYSICS AND BIOINFORMATICS COURSE (NEP-PGCF)

First year (Common in Program Structure 1, 2 and 3)

Semester-2

	Credits in each course			
Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC04: Computational Biology and Bioinformatics	3	0	1	4
BP-DSC05: Cellular Biophysics and Bioenergetics	3	0	1	4
BP-DSC06: Genetic Engineering	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE04: Environmental Biophysics	3	1	0	4
BP-DSE05: Biophysical methods: Fundamental Techniques	3	0	1	4
BP-DSE06: Text Mining Methods in Biology	3	0	1	4
Generic Elective courses*				
#BP-DSE04: Environmental Biophysics	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
BP-SBC02: Specialised Laboratory – II: Cell Biology and Bioinformatics	0	0	2	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
-	-	-	-	-
Total credits				22

***** *(a student can opt for either two DSE course, or one DSE with one GE)*

#BP-DSE04 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

Second Year: Program Structure -1 (PG with only coursework)

Semester-3

	Credits in each course			
Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC07: Physiological Biophysics	3	0	1	4
BP-DSC08: High-Throughput Biology	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE07: Biophysical Methods: Frontiers	3	1	0	4
BP-DSE08: Biomolecular Interactions	3	0	1	4
BP-DSE09: Infection and Immunity	3	0	1	4
BP-DSE10: Protein Aggregation, misfolding and disorders	3	0	1	4
Generic Elective courses*				
#BP-DSE07 Biophysical Methods: Frontiers	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
BP-SBC03: Specialised Laboratory – III: Protein Chemistry	0	0	2	2
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based Research				
-	-	-	-	-
Total credits				22

* *student can opt for either three DSE OR two DSE with one GE*

#BP-DSE07 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

Semester-4

Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC09: Cellular and molecular neurophysiology	3	0	1	4
BP-DSC10: Molecular Biophysics	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE11: Computer Aided Drug Design	3	1	0	4
BP-DSE12: Combating rare diseases: leveraging in-silico approaches	3	0	1	4
BP-DSE13: Protein Engineering and applications	3	0	1	4
BP-DSE14: Artificial Intelligence, Machine learning and Deep Learning in Biomedical sciences	3	0	1	4
Generic Elective courses*				
#BP-DSE11: Computer Aided Drug Design	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
BP-SBC-04: Specialised Laboratory – IV: Advanced Analytical Methods	0	0	2	2
Research Methods/ Tools/ Writing				

-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based Research				
-	-	-	-	-
Total credits				22

*****_student can opt for either three DSE OR two DSE with one GE_

#BP-DSE11 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

Second Year: Program Structure -2 (PG with Coursework and Research)

Semester-3

	Credits in each course			
Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC07: Physiological Biophysics	3	0	1	4
BP-DSC08: High Throughput Biology	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE07: Biophysical Methods: Frontiers	3	1	0	4
BP-DSE08: Biomolecular Interactions	3	0	1	4
BP-DSE09: Infection and Immunity	3	0	1	4
Generic Elective courses*				
#BP-DSE07 Biophysical Methods: Frontiers	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
-	-	-	-	-
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based Research				
Dissertation: Intensive problem-based research	0	0	6	6
Total credits				22

** student can opt for either two DSE OR one DSE and one GE*

#BP-DSE07 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

Semester-4

Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
BP-DSC09: Cellular and molecular neurophysiology	3	0	1	4
BP-DSC10: Molecular Biophysics	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE11: Computer Aided Drug Design	3	1	0	4
BP-DSE12: Combating rare diseases: leveraging in-silico approaches	3	0	1	4
BP-DSE13: Protein Engineering and applications	3	0	1	4
Generic Elective courses*				
#BP-DSE11: Computer Aided Drug Design	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
-	-	-	-	-
Research Methods/ Tools/ Writing				
-	-	-	-	-
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based Research				
Dissertation: Intensive problem-based research continuation from previous semester	0	0	6	6
Total credits				22

** student can opt for either two DSE OR one DSE and one GE*

#BP-DSE11 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

Second Year: Program Structure -3 (PG with Research)

Semester-3

	Credits in each course			
Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses*				
BP-DSC07: Physiological Biophysics	3	0	1	4
Discipline Specific Elective (DSE) courses*				
#BP-DSE07: Biophysical Methods: Frontiers	3	1	0	4
BP-DSE08: Biomolecular Interactions	3	0	1	4
BP-DSE09: Infection and Immunity	3	0	1	4
Generic Elective courses*				
#BP-DSE07 Biophysical Methods: Frontiers	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
-	-	-	-	-
Research Methods/ Tools/ Writing				
BP-RT01: Advanced Research Methodology	2	0	0	2
BP-RT02: Tools for Research	2	0	0	2
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based Research				
Dissertation: Intensive problem-based research	0	0	10	10
Total credits				22

** student can opt for any one DSE*

#BP-DSE07 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

Semester-4

Course	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
-	-	-	-	-
Discipline Specific Elective (DSE) courses*				
#BP-DSE11: Computer aided drug design	3	1	0	4
BP-DSE12: Combating rare diseases: leveraging in-silico approaches	3	0	1	4
BP-DSE13: Protein Engineering and applications	3	0	1	4
General Elective courses*				
#BP-DSE11: Computer Aided Drug Design	3	1	0	4
Skill-based course/ workshop/ Specialized laboratory/ Hands on Learning				
-	-	-	-	-
Research Methods/ Tools/ Writing				
BP-RT03: Techniques for Research Writing	2	0	0	2
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based Research				
Dissertation: Intensive problem-based research continuation from previous semester	0	0	16	16
Total credits				22

** student can opt for any one DSE*

#BP-DSE11 is designed to be of Interdisciplinary nature and is open to students from other departments as well.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC01: BIOPHYSICAL CHEMISTRY

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		
BP-DSC01: BIOPHYSICAL CHEMISTRY	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to introduce the students to the essentials of biophysical perspectives in daily biology.
- The student will understand association of molecules.
- They will be understand the drug delivery vehicles and preparation.
- The students will be delivered the knowledge about role of thermodynamics in biological systems and how hydrodynamics play a role in biological interactions
- The students will be motivated to learn the vitamin's role and behaviour of animals and how they learn and keep memorize the events during their life cycle.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to use different equation and theory to prepare the biological solutions.
- Student will be able to analyse the association process of macromolecules.
- Student will be able to learn about effect of drugs on biomacromolecules.
- Student will be able to study the various high affinity interactions and behaviour and learning of animals.

SYLLABUS OF BP-DSC-01

Theory component (45 hours)

UNIT I **(20 hours)**

Electrostatics, Simple Salts: Debye-Huckel Theory, Buffering systems used in biochemistry; Handerson-Haselbach equation, Factors affecting structure and stability of macromolecule, chemical kinetics: association and dissociation reactions in biology Self-Assembly and Polymerization

UNIT II **(10 hours)**

Biological functions of carbohydrates, mutarotation and tautomerism, formation of liposomes and role in drug delivery systems

UNIT III **(5 hours)**

Role of energetics and thermodynamics to study protein-ligand interactions, detailed perspective of protein DNA/hydrodynamics

UNIT IV **(10 hours)**

Vitamins and their role as co-enzymes, hormones: functions and disorders, high affinity interactions and their role in biophysics: biotin and streptavidin, Antigen-antibody interactions, affinity and avidity, repurposing of drugs, biophysical perspective of neurobiology: learning and memory, animal behaviour

Practical component (30 hours)

UNIT I **(20 hours)**

Preparation of biological solution in different mediums, experiments to analyse self-association of proteins (eg. Lysozyme), effect of ligands on the structure and stability of protein.

UNIT II **(10 hours)**

Protein-drug binding assays, DNA-drug binding assays

Essential/recommended readings

Theory:

1. David Sheehan; PHYSICAL BIOCHEMISTRY: PRINCIPLES AND APPLICATIONS; John Wiley & Sons Ltd
2. Freifelder, David Michael; Physical biochemistry : applications to biochemistry and molecular biology; W.H. Freeman and Company.
3. Wilson And Walker; Principles And Techniques Of Biochemistry And Molecular Biology; CAMBRIDGE UNIVERSITY PRESS

Practicals:

1. Wilson And Walker; Principles And Techniques Of Biochemistry And Molecular Biology; CAMBRIDGE UNIVERSITY PRESS
2. Holger Gohlke; Protein-Ligand Interactions; Willey VCH.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC02: MOLECULAR BIOLOGY

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		
BP-DSC02: **MOLECULAR BIOLOGY**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to introduce the students to the essential concepts of molecular biology.
- The students will learn about the physical and chemical architecture of the genomes and genetic material of organisms across all kingdoms of organisms.
- They will become familiar with molecular mechanisms of DNA replication, transcription, translation, DNA repair, and gene regulation in prokaryotic and eukaryotic organisms.
- The student will study the techniques and perform experiments related to the subject to understand these mechanisms.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to describe the structures of DNA/RNA, and genome organization of prokaryotes and eukaryotes.
- Students will be able to compare and contrast the mechanisms of bacterial and eukaryotic DNA replication, transcription, and translation.
- Students will be able to utilize concepts of DNA repair and recombination as molecular biology tools to design therapeutic solutions to various genetic disorders.
- Students will be able to explain gene regulation occurring at various levels in both prokaryotic and eukaryotic organisms.
- Students will be able to describe post-transcriptional processes, RNA editing, RNAi and miRNA processing.
- Students will be able to describe the translation mechanism in prokaryotes and eukaryotes, regulation of translation, and post-translational processing

SYLLABUS OF BP-DSC02

Theory component (45 hours)

UNIT I **(5 hours)**

Nucleic acid structure and function: DNA double helix: endo- and exo sugars, syn- and anti- conformation of N-bases, W-C and Non-W-C base pairing, roll, slide and twist in DNA; DNA supercoiling: Supercoiling, superhelical density, Lk, Wr and Tw, topoisomerases; DNA melting; RNA structure.

UNIT II **(5 hours)**

Introduction to genomes: Genome architecture of bacteria, eukaryotes, organelle, and viruses; Linear and circular chromosomes, single-stranded and doubles stranded DNA/RNA viral genome; Organization of genes and chromosomes: Operon, unique and repetitive DNA, interrupted genes, gene families, structure of chromatin and chromosomes, DNase I sensitive regions, heterochromatin, euchromatin, DNA methylation.

UNIT III **(9 hours)**

DNA replication: Chemistry of replication, arrangement of replicons in a genome, various modes of replication, DNA polymerases and other replication enzymes; Synthesis of leading and lagging strands; DNA replication in prokaryotes and eukaryotes: initiation, elongation, and termination; Telomere maintenance and chromatin assembly; Segregation of chromosomes to daughter cells; Regulation of replication, DNA copy number maintenance,

UNIT IV **(9 hours)**

DNA repair and recombination: DNA damage: pyrimidine dimer, nick and gap in DNA, AP sites, base mispairing; Mismatch, base excision and nucleotide-excision repair mechanisms, SOS response; Non-homologous end joining (NHEJ); Homologous recombination; Recombination as a molecular biology tool: CRISPR-Cas systems for editing, regulating and targeting genomes; Transposition: DNA transposons and retroposons and mechanism.

UNIT V **(9 hours)**

Transcription and RNA processing: Prokaryotic transcription**:** RNA polymerase, promoters, sigma factors, initiation, elongation and termination (Rho-dependent and independent); Eukaryotic transcription: types of RNA polymerases, promoters and enhancers, transcription factors, TBP and TAFs; RNA processing and modification: splicing, alternative splicing, capping, polyA addition, rRNA processing, base modification, tRNA processing, and modifications; RNA editing: RNAi and miRNAs, antisense RNA; Post-transcriptional gene regulation.

UNIT VI **(8 hours)**

Translation: The genetic code; Translation initiation, elongation, termination, ribosome recycling in prokaryotes and eukaryotes; IRES in eukaryotes; Codon anticodon interaction; Polycistronic and monocistronic synthesis; Regulation of gene expression in prokaryotes (operons, sigma factors, anti-sigma factors, anti-sense RNA) and eukaryotes (RNA

stability, UTR regulation, Riboswitch, RNA interference); Post-translational gene regulation; Covalent modification of proteins: phosphorylation, methylation, acetylation adenylation, arginylation; *In-vitro* translation systems.

Practical component (30 hours)

1. Preparation of buffers, reagents, and media.
2. Isolation of genomic DNA of *E. coli*.
3. Isolation of plasmid DNA of *E. coli*.
4. Estimation of DNA/protein concentration using spectroscopy.
5. Analyzing various biophysical conformations of the plasmid DNA using agarose gel electrophoresis.
6. Extraction of DNA from agarose gel.
7. Setting up of PCR reaction for gene amplification.
8. Analysis of PCR-amplified product using agarose gel filtration

Essential/recommended readings

1. Gene IX by Benjamin Lewin. Jones and Bartlett Publishers. 2007.
2. Molecular Biology by R.F. Weaver, 4thedition. McGraw Hill, USA. 2007.
3. Molecular Biology of the Gene by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. 6th edition. Benjamin Cummings. 2007.
4. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter. 5th edition. Garland Science, New York and London. 2007.
5. Biochemistry by J. M. Berg, J. L. Tymoczko, L. Stryer. 5th edition. W.H. Freeman and Company, USA. 2008.
6. Current Protocols in Molecular Biology edited by: F. M. Ausubel, R. Brent, R.E. Kingston, D. D. Moore, J. A. Smith, K. Struhl. John Wiley and Sons, Inc. 2007.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC03: PROTEIN SCIENCE: EMERGING FRONTIERS

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		
BP-DSC03: PROTEIN SCIENCE: EMERGING FRONTIERS	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to provide students with an in-depth knowledge of the role of proteins in cellular systems; including their molecular structure, biological function and evolution.
- Students will gain an understanding of the historical development of protein science, including key discoveries.
- The student will learn about the evolution of the experimental techniques used to study proteins in the lab.
- The students will be motivated to analyse the future research directions in protein science.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will gain a comprehensive understanding of protein biochemistry, including how proteins fold, function, and evolve.
- The student will be able to understand the relationship between structure and function of proteins. They will be able to appreciate how protein folding influences biological activity.
- The students will come to appreciate how evolutionary studies foretell the sequence-structure-function relationships among proteins.
- The students will come to appreciate the variations in protein structure generated through post-translation modifications.
- The students will be able to trace the timeline of significant breakthroughs in protein biochemistry, and appreciate the interdisciplinary nature of protein research, critically analyze the impact of these discoveries on modern applications in biotechnology and medicine.

SYLLABUS OF BP-DSC03

Theory component (45 hours)

UNIT I: Protein Structure and Function (6 hours)

- Overview of Protein structure: Amino acids and peptide bonds, Levels of protein structure - primary, secondary, tertiary, and quaternary
- Overview of Protein functions: enzymes, structural components, signaling, and transport
- The relationship between protein structure and function: protein domains and structural motifs
- The evolution of function through structural divergence and convergence
- Techniques to study protein structure and function: X-ray crystallography, Nuclear magnetic resonance (NMR) spectroscopy, Computational approaches

UNIT II: Protein Folding and Stability (8 hours)

- Introduction to the protein folding problem: Past and current theories of protein folding, Anfinson's Dogma, Levinthal's paradox, Molten globules, Folding landscapes, Thermodynamics and kinetics of protein folding.
- Cellular Proteostasis: Chaperones and protein folding machinery.
- Traditional and novel approaches to explore protein folding-unfolding pathways.
- Introduction to Inteins, prosequences and their role in generating structural variants.

UNIT III: Post translation modifications (4 hours)

- Overview of protein translation modifications (PTMs): Types and methods for detecting PTMs, Functional implications of PTMs in cellular processes and diseases

UNIT IV: Protein-protein Interactions (4 hours)

- Overview of protein-protein interactions (PPIs): Methods for detecting PPIs (yeast two-hybrid, co-immunoprecipitation), Functional implications of PPIs in cellular processes.
- Liquid-liquid phase separation: principles and examples.

UNIT V: Intrinsic Disorder in Proteins (4 hours)

- Overview of Intrinsically disorder in proteins (IDPs): Methods for detecting Intrinsic disorder, Computational predictions, Functional implications of intrinsic disorder in proteins.

UNIT VI: Proteins in diseases (5 hours)

- Protein Misfolding diseases (e.g., Alzheimer's, Parkinson's), prion diseases
- Genetic mutations and their effects on protein function (cystic fibrosis, sickle cell anemia)

UNIT VII: Protein structure analysis and engineering (8 hours)

- Structural analysis and comparison, Prediction of protein function from structure
- Protein engineering methods: directed evolution, site-directed mutagenesis, applications in biotechnology- artificial proteins (designed enzymes, therapeutic proteins)
- Targeting proteins for therapeutic intervention: Drug development, Protein-ligand binding studies, Immunotherapy and protein-based vaccines.
- Protein immobilization and application

UNIT VIII: The future of Protein Science **(6 hours)**

- The role of AI in protein structure and function prediction- AlphaFold and beyond
- Future challenges in protein science- Biomolecule Design

Practical component (30 hours)

UNIT 1: Databases/Webservers for analysing the following:
1) Protein structures: ex PDB
2) Protein Domains and motifs: ex MEME, CDD, ProSite
3) Protein structural comparison and classification: ex SCOP/CATH
4) Protein function prediction: ex ProFunc
5) Protein-protein interactions: ex STRING, HProteome-BSite, CORUM, BindingDb
6) Post translation modifications: ex dbPTM, UniProt
7) Protein motion and dynamics: ex ProThermDB, MobiDb, Molmovdb
8) Protein evolution: ex DIVERGENCE
9) Protein structure and feature visualization: ex Proteopedia
10) Protein intrinsic disorder: ex DisProt,
11) Protein conformation Diversity: ex PCDB
12) Other Miscellaneous databases: ex RING, VFDB, CAMP

Essential/Recommended readings

Theory:

- **Books:**

1) Lesk, A. M. (2010). Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press.
2) Jenny, Gu & Phillipe, E. Bourne (2009). Structural Bioinformatics. Wiley-Blackwell.

- **Online Resources**:

Databases as discussed in practical component

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE01: CELLULAR PROTEOMICS

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		
BP-DSE01: **CELLULAR PROTEOMICS**	**4**	**3**	**1**	**0**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course is intended to introduce the student to the principles and practical considerations of animal and plant cell and tissue culture.
- Introduces the practice and process of culturing animal cells and cell lines in a laboratory. Focuses on routine maintenance and record-keeping, including media preparation, cryopreservation, and troubleshooting common culture problems.
- To introduce the utility of proteomics and its potentials to understand complex biological phenomenon and problems.

Learning outcomes

Upon completion of the course students should be able to:

- Successfully maintain cultures of animal cells and established cell lines with good viability, minimal contamination and appropriate documentation.
- Perform supportive or episodic tasks relevant to cell culture, including preparation and evaluation of media, cryopreservation and recovery, and assessment of cell growth/health.
- Recognize and troubleshoot problems common to routine cell culture.
- The students will have strong foundations and first hand scientific understanding of current trends in Proteomics.

SYLLABUS OF BP-DSE01

Theory Component (45 hours)

UNIT I **(15 hours)**

Biology of the Cultured Animal Cells, Tissue & Organ: Historical, Advantages and limitations - medical/pharmaceutical products of animal cell culture and their applications. Risks in a tissue culture laboratory and safety biohazards.

Facilities for animal cell culture: Infrastructure, Equipments including Biosafety Cabinets and Laminar Air Flow, Culture vessels types (treated, Non-treated surfaces), the substrate, Nitrogen Container, CO2 incubator, Filters-sizes, types (for aqueous solution, for DMSO soluble solution). Biology and characterization of cultured cells-cell adhesion, proliferation, differentiation, morphology of cells and identification. Evolution of cell lines, development of continuous cell lines,

Culture Media: Balanced salt solutions, Complete media including proliferation, differentiation, Freezing and wash media. Chemical, physical and metabolic functions of different constituents of culture medium. Role of CO2, Serum and Supplements. Serum free media and their application: advantages and disadvantages of serum and serum free media, replacement of serum and development of serum free media.

Unit II **(10 hours)**

Primary Cell Cultures and Sub-cultures: Types of primary cell culture, isolation of the tissue and preparation of primary cell culture, characteristics of limited life-span cultures, Techniques (mechanical disaggregation, enzymatic treatment, separation of viable and non-viable cells); Subculture and propagation

Cell Lines and Characterization: Establishment and properties of continuous cell lines; Characterization, authentication (lineage or tissue markers), cell morphology, chromosome content, DNA content, RNA and protein expression, enzyme activity, antigen markers.

Cell Cloning: Cloning techniques, dilution and suspension cloning, scaling up in suspension and monolayer, large scale production of cells using bioreactors, special requirement of cells growing at very low densities.

Stem Cell Culture Embryonic and adult stem cells and their applications. Satellite Cells. Totipotent, Pluripotent and Multipotent stem cells.

Unit III **(5 hours)**

Applications of Animal Cell Culture: Production of high value therapeutics (enzymes, hormones, monoclonal antibody, cytokines etc), virology, cancer research, gene therapy, drug development and cytotoxicity, cryopreservation of cells.

Unit IV **(15 hours)**

Protein structure and function, An overview of systems biology, Evolution from protein chemistry to proteomics, Protein expression systems, Protein purification techniques, Protein molecular modifications for purification, Various expression systems for recombinant protein production

Protein characterization methods - I: Based on mass &size,

II: Based on electromagnetic property, Surface Plasmon Resonance, Isothermal Titration Calorimetry, Differential Scanning Calorimetry

Analysis of protein-protein interactions ,Introduction to Proteomics, Interactomics Pull-down assay using tagged protein, Yeast two hybrid system, Co-immunoprecipitation assay, Protein crosslinking methods , Photoreactive crosslinking, Analytical centrifugation, Fluorescence resonance energy transfer (FRET),Protein fragment Complementation assays, Hydrogen Deuterium Exchange (HDX) massspectrometry, Phage display, Hybridoma culture

Tutorial Component (15 hours)

- Good lab practices for *in vitro* culture,
- Aseptic maintenance of cell culture,
- Generation of Stable cell lines,
- introduction to various Cell based assays.

Essential/Recommended readings

Theory:

- **Books:**

Latest editions of following books are recommended:

i. Culture of Animal cells 4th Edi by Freshney, R.I.
ii. Animal cell culture- practical approach by Edi. Jhon R.W. Masters ; Oxford
iii. Introduction to Protein Structure, Carl Branden & John Tooze, Garland Science.
iv. Proteomics: From protein sequences to function, S.R. Pennington & M.J. Dunn, Bios
Scientific Publishers.
v. Biophysical Chemistry, Charles R. Cantor & Paul R. Schimmel, Freemann & Company.
vi. Animal cell culture- practical approach by Edi. Jhon R.W. Masters ; Oxford
vii. Protein Biochemistry and Proteomics (The Experimenter Series), R.Hubert, Academic Press,

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE02: STATISTICS & PROGRAMMING FOR LIFE SCIENCES

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		
BP-DSE02: **STATISTICS & PROGRAMMING FOR LIFE SCIENCES**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- analyze different types of high-throughput datasets
- construct analysis modules in statistical programming packages
- use different R-packages to analyze the biological data.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Understanding of different components of a computer program
- Apply R for inference from data
- Use R-studio to write R scripts
- Reading and importing data from CSV, Excel, and text files into R
- Creating publication-ready plots
- Apply selected probability distributions to solve problems
- Apply and evaluate different learning algorithms and model selection.

SYLLABUS OF BP-DSE02

Theory component (45 hours)

UNIT I **(3 hours)**

Basics of Programming: Introduction to Perl/C/Python, Flowcharting, Decision table, Algorithms, Structured programming concepts, Concept of data-structure, if-else loops and decision, Use and definition of sub-routines.

UNIT II **(2 hours)**

Introduction to R Language and Environment of Statistical Computing and Graphics: Introduction to R, Getting Started - R Console, Data types and Structures, Exploring and Visualizing Data, Programming Structures, Functions, and Data Relationships.

UNIT III **(2 hours)**

Introduction to R-studio: R-studio screen, Workspace tab, History tab, Defining and Setting Working directory, Making script in R-studio, Installing and saving packages, Plotting different type of graphs.

UNIT IV **(8 hours)**

Introduction to different types of data in biology; Descriptive statistics like mean, median, mode, quartiles, standard deviation, standard error; Different types of plots like scatter plot, bar graph, line graph, pie chart, box plot, frequency histogram; Understanding error bars.

UNIT V **(10 hours)**

Probability and probability distributions: basic concepts of probability, conditional probability, Bayes theorem; binomial, multinomial, Poisson, exponential, and Gaussian distribution;

UNIT VI **(10 hours)**

Sampling distribution and central limit theorem. Hypothesis testing: Student's t-test, Z-test, Chi-squared test, ANOVA. Correlation, regression and estimation: Pearson correlation; Regression: linear, non-linear, single and multivariate; concept of likelihood and method of maximum likelihood.

UNIT VII **(10 hours)**

Tools for data of high throughput experiments: principle component analysis; Clustering of data: K-means algorithm, hierarchical clustering; Visualization tools: heat map, volcano plot.

Practical component (30 hours)

UNIT I **(10 hours)**

- Installation of R, R-studio and RMarkdown.
- Concepts of Command line, Procedural workflow, Working with variables, sequences, lists
- Working with loops
- Defining Functions
- Implementation of R-Loops with different examples.
- Implementation of data frames in R. Write a program to join columns and rows in a data frame using c bind () and r bind () in R.
- Making pie and bar charts using R.
- Performing statistical analysis on the given data using R.

UNIT II **(10 hours)**

- Writing an R program
    - to find Correlation and Covariance
    - for Regression Modeling.

UNIT III **(10 hours)**

- Writing an R program
    - to cluster data
    - derivation of principal components
    - draw volcano plot and heat map

Essential/recommended readings

Theory:

1. Statistical methods in Bioinformatics: An introduction (second edition). Warren. Ewens and Gregory Grant. ISBN: 0-387-40082-6
2. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids (first edition). Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison. ISBN: 978-0521540797

Practicals:

1. Beyond Spreadsheets with R: A beginner's guide to R and RStudio (first edition). ISBN: 978-1617294594

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE03: VACCINES AND BIOTHERAPEUTICS

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		
BP-DSE03: **VACCINES AND BIOTHERAPEUTICS**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of the course is to provide students with an overview of current developments in different areas of vaccines.
- To make students understand the basic concepts of activation of the immune system during infections and in response to various vaccine immunizations.
- To teach students about different vaccine formats and the advantages/limitations associated with individual formats.
- To introduce students to biotherapeutics and its role in supporting human medicine.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will understand the fundamental concepts of the human immune system and basic immunology.
- Students will be able to understand and differentiate the immune responses with respect to infection and vaccination.
- Students will learn about different types of vaccines and their applications in the health sector.
- Students will learn to correlate the specific requirements of using a particular type of vaccine format with a particular disease condition.
- Students will understand the importance of both the conventional and new emerging vaccine technologies.
- Students will understand about the use of biomolecules and cells as therapeutic agents.
- Students will learn different technologies used in the production of biotherapeutics.

SYLLABUS OF BP-DSE03

Theory Component (45 hours)

UNIT I **(10 hours)**

Immune system and infection: Overview of Immune system; Effectors of the immune system; Innate and adaptive immunity; Activation of innate immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection; Immune response to infection; Protective immune response in bacterial, viral and parasitic infections; Primary and secondary immune responses during infection; Antigen presentation and role of antigen presenting cells: Dendritic/macrophages/B-cells; Humoral (antibody-mediated) responses; Cell-mediated responses: role of CD4+ and CD8+ T cells; Memory responses: memory and effector T and B cells, generation and maintenance of memory T and B cells.

UNIT II **(10 hours)**

Vaccination, Adjuvants, and Immune potentiators: Vaccination and immune response: route of vaccination – oral, intranasal, subcutaneous, intramuscular, and intravenous route; Vaccine components: Antigens, Adjuvants [mineral salts (Aluminum hydroxide, Calcium alginate), emulsion and surfactant-based formulations (MF59 and AS03), particulate delivery vehicles (microparticles, immune-stimulating complexes, VLPs), liposomes]; Immune potentiators: microbial derivatives (Monophosphoryl lipid A, CpG oligonucleotide, lipopolysaccharide, Bordetella pertussis, BCG), cells and cytokines/hormones (dendritic cells, IL-12 and GM-CSF); Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems (microbial adjuvants, liposomal and microparticles); Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and mucosal immunity.

UNIT III **(6 hours)**

Vaccine types, and design: History of vaccines; Conventional vaccines; Bacterial vaccines; Viral vaccines; Cancer vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Types of vaccines - live attenuated and inactivated vaccine, killed whole organism, toxoid, subunit vaccines, virus-like-particle, outer membrane vesicle, protein-polysaccharide conjugate, viral vectored, nucleic acid vaccine (DNA/mRNA), bacterial vectored, and antigen-presenting-cells.

UNIT IV **(7 hours)**

Introduction to Vaccine Technologies: New Vaccine Technologies; Rationally designed vaccines; DNA vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (vaccine delivery systems); Disease-specific vaccine design: tuberculosis vaccine; malaria vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika, Corona); Case studies.

UNIT V **(12 hours)**

Biotherapeutics: Molecular biology basics: DNA structure and function, gene expression regulation, protein structure and function, recombinant DNA technology; Protein Engineering: protein design and optimization, antibody engineering, protein purification techniques, protein stability and delivery mechanisms; Cell and Tissue Engineering: stem cell biology, cell culture techniques, tissue engineering strategies, regenerative medicine applications; Immunotherapy: Immune system components and functions, T-cell receptor engineering, Checkpoint inhibitors, CAR-T cell therapy; Gene Therapy: viral vector design, gene editing technologies (CRISPR), gene therapy delivery methods, clinical applications of gene therapy; Drug Delivery Systems: targeted drug delivery, nanomedicine approaches, biodegradable polymers, drug delivery to

specific tissues; Clinical trials and regulatory aspects; Biomanufacturing processes; Ethical and societal implications.

Practical component (30 hours)

1. Understanding the nature of antigens found in pathogens through studying the cases of infections of bacterial, viral, fungal origin, reported in literature.
2. Understanding the elicitation of microbial specific immune response in humans, through reported literature and drawing correlation between the microbes and the type of host response that generally resolves the infection.
3. Based on the above information, practicing the designing of suitable vaccine candidates, anticipating to elicit a desired immune response leading to preventive immunity against the pathogen.
4. Categorizing various in-use vaccines into their respective types to understand the common features of multiple formats that have become successful for a particular type of pathogen/infection.
5. Finding out the infections of present times for which vaccines are not available.
6. Choosing one infection and its causative pathogen, proposing a hypothesis about the most suitable vaccine format for its prevention. Attempting to draw a flow chart of vaccine development proposal starting from the stage of antigen selection to the stage of product production.
7. Presenting the vaccine ideas through a class seminar.
8. Understanding the relevance of antibodies in vaccine effectiveness/potency through case studies of the reported vaccines, e.g. anti-hepatitis B virus, HBsAg vaccine.
9. Understanding the relevance of cellular immunity for the effective prevention of viral infections through studies against viral vaccines, e.g. Covaxin and Covishield.
10. Understanding the relevance of vaccines for managing various cancers through case studies, thereby identifying the underlying bottlenecks of research in this area.
11. Understanding the concepts of antibody engineering and undertaking a small project to find targets for designing therapeutic antibody molecule(s) for a contemporary disease with the help of literature and databases.

Essential/recommended readings

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology:the Immune System in Health and Disease. USA: Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). Kuby Immunology. New York: W.H. Freeman.
3. Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.
4. Vaccinology: Principles and Practice, by Editors: W. John W. Morrow, Nadeem A. Sheikh, Clint S. Schmidt, D. Huw Davies; Wiley Blackwell, 2012
5. Gene IX by Benjamin Lewin. Jones and Bartlett Publishers. 2007.
6. Cleland and Craik, (2006), *Protein Engineering*, *Principles and Practice*, Vol 7, Springer, Netherlands.
7. Huang, N.F., L'Heureux, N., Song, L. (2018) Engineering Stem Cells for Tissue Regeneration. World Scientific Publishing Company.
8. Pelengaris, S. and Khan, M. (2013). The Molecular Biology of Cancer. Wiley-Blackwell, Publication, New Jersey.
9. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

SKILL BASED COURSE – BP-SB01: SPECIALISED LABORATORY – I: Molecular Biology

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		
BP-SB01 **SPECIALISED LABORATORY –I: Molecular Biology**	**2**	**0**	**0**	**2**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this skill enhancement laboratory course is to provide practical skills on basic microbiological techniques.
- To expose students to the microbiology lab environment, basic lab infrastructure, basic equipment handling, and safety guidelines.
- To develop skilled manpower capable of handling basic lab strains of bacteria e.g. *E. coli,* for future molecular biology and genetic engineering experiments.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- To students will be able to isolate, characterize and identify common bacterial organisms.
- Students will be able to calculate/determine the bacterial load of different samples.
- Students will be able to perform antimicrobial sensitivity tests.
- Students will learn about preserving bacterial cultures of short and prolonged durations.

SYLLABUS OF BP-SB01

Unit I (60 hours)

1. Introduction to sterilization, disinfection and safety in microbiological laboratory.
2. Introduction to basic microbiology laboratory equipment and handling.
3. Preparation of culture media and pouring plates.
4. Isolation of bacteria in pure culture by the streak plate method.
5. Isolation of bacteria in pure culture by the serial dilution method.
6. Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus, Streptococcus, etc.*
7. Growth of bacterial culture and preparation of growth curve.
8. Preparation of bacterial smear and Gram's staining.
9. Enumeration of bacteria: standard plate count.
10. Antimicrobial sensitivity test and demonstration of drug resistance.
11. Preparation of stock cultures: slants and stabs and glycerol stock cultures
12. Determination of Minimum Inhibitory Concentration (MIC)
13. Isolation and identification of bacteria from soil/water samples.
14. Colony PCR
15. Analysis of PCR product and its size using agarose gel electrophoresis.
16. Case Study/Group discussing: on data analysis and results

Essential/recommended readings

1. Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company.
2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins and Lyne's Microbiological Methods (8th ed.). Arnolds.
3. Tille, P. M., & Forbes, B. A. Bailey & Scott's Diagnostic Microbiology.
4. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE – BP-DSC04: COMPUTATIONAL BIOLOGY AND BIOINFORMATICS

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		
BP-DSC04: **COMPUTATIONAL BIOLOGY AND BIOINFORMATICS**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- find and access relevant information from different databases
- apply various algorithms to predict the study function and evolution of biological macromolecules.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students would be able to learn about the different types of molecular biology databases and formats in which data is stored in these data repositories.
- Students would learn about the initiatives taken by the global and Indian scientific communities to make the available data
- Students would be able to understand the concept of different forms of sequence alignment methods and the selection of appropriate alignment method
- Students would know the mechanisms of molecular evolution. He/she would be able to draw phylogenetic inferences and will be able to reconstruct phylogenetic trees based on several molecular markers and application of the State-of-the-Art bioinformatics tools
- Students would know about different types of genome sequencing methods and their usage in modern biomedical techniques.
- Students would know different features used to annotate a genome/ DNA sequence of interest. Interpret the genome annotation results and meaning of a biologically functional region.

SYLLABUS OF BP-DSC04

Theory component (45 hours)

UNIT I **(8 hours)**

Introduction; Types of databases in terms of biological information content; Protein and gene information resources; Specialized genomic resources; Different formats of molecular biology data; Selected examples of global and Indian Biological Data Repositories. Recent advances w.r.t. Biological data repositories.

UNIT II **(10 hours)**

Global and local alignment; Methods and algorithms of pairwise and multiple sequence alignment; Concept and use of alignment scoring matrices; Gene/protein and genome alignment methods; Database similarity searching using sequence alignment; Motif detection; Concept and use of protein families. Recent advances in Sequence alignment.

UNIT III **(7 hours)**

Concept of orthology, paralogy and homology in gene and protein sequences. Methods and tools for phylogenetic analysis; Creation, evaluation and interpretation of evolutionary trees; Advantages and disadvantages of phenetic and cladistic approaches. Recent advances w.r.t. molecular phylogenetics.

UNIT IV **(10 hours)**

Different Generation of DNA sequencing technologies; Standard formats of sequencing reads; Applications of DNA sequencing technologies (Genome sequencing, Transcriptomics, ChipSeq, metagenomics); Recent advances w.r.t. Sequencing technologies.

UNIT V **(10 hours)**

Organization and structure of prokaryotic and eukaryotic genomes - gene structure, exon, intron, ORF, CDS, UTR, alternative splicing, codon usage, Gene prediction methods – *ab-initio*, Homology & transcriptome/EST, Non coding RNA discovery and annotation. Functional annotation of genes - sequence homology-based annotation & Gene Ontology/ Pathway Mapping using Swiss-Prot, KEGG, and ENZYME database.

Practical component (30 hours)

UNIT I **(5 hours)**

- Exploring the NCBI, UniProtKB, IBDC data repositories and tools available there.

UNIT II **(20 hours)**

- Retrieving the DNA sequence of a given item (by name or accession number) from GENBANK.
- Retrieving this protein sequence of a given organism from UniProtKB database.
- Performing a database search using the BLAST.
- Short-listing protein sequences of the highest similarity from the list of BLAST search results and doing a multiple sequence alignment (Using CLUSTALW or any other multiple sequence alignment tool).
- Performing functional annotation of a newly sequenced genome.

UNIT III **(5 hours)**

- Learning about the Phylip/MEGA program and its uses for the construction of phylogenetic trees

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Essential/recommended readings

Theory:

1. Statistical methods in Bioinformatics: An introduction (second edition). Warren. Ewens and Gregory Grant. ISBN: 0-387-40082-6
2. Bioinformatics (fourth edition). Edited by Andreas D. Baxevanis, Gary D. Bader, David S. Wishart. ISBN: 978-1-119-33558-0.
3. A Cell Biologist's Guide to Modeling and Bioinformatics (first edition). Raquell M. Holmes ISBN: 978-0-470-13934-9
4. Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids (first edition). Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison. ISBN: 978-0521540797
5. Bioinformatics and Functional Genomics (third edition). Jonathan Pevsner. ISBN: 978-1-118-58176-6
6. The Phylogenetic Handbook: A Practical Approach to DNA and Protein Phylogeny (first edition). Marco Salemi, Anne-Mieke Vandamme (editors). ISBN: 0-521-80390-X.

Practical:

1. Bioinformatics for Dummies (second edition). Jean-Michel Claverie and Cedric Notredame. ISBN: 978-0-470-08985.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC05: CELLULAR BIOPHYSICS AND BIOENERGETICS

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		
BP-DSC05: **CELLULAR BIOPHYSICS AND BIOENERGETICS**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will be able to enumerate enumerate the various pathways controlling the cell viability and function
- Students will understand the physical principles involved in cell function maintenance.
- Students will understand the integration of principles of energetics to cellular systems.

Learning Outcomes

The Learning Outcomes of this course are as follows.

- Should understand the structural organization &function of living cells.
- Should understand the biophysical principles of cellular mechanism of signaling.
- Should understand the principles of healthy development of an embryo and its protection.
- Should understand the biophysical principles of programmed cell death & their relevance in cancer.
- Should be able to apply thermodynamics in cellular & biochemical processes.

SYLLABUS OF BP-DSC05

Theory component (45 hours)

UNIT I **(10 hours)**

The Dynamic Cell: Architecture and Life Cycle of Cells, Cells into Tissues. Cell Organization: Microscopy and Cell Architecture, Organelles of the Prokaryotic/Eukaryotic Cell. Regulation of Eukaryotic Cell Cycle: Overview of the Cell Cycle and its Control, Biophysical Principles of Molecular Mechanisms for Regulating Mitotic Events, Checkpoints in Cell-Cycle Regulation.

UNIT II **(10 hours)**

Biophysics of Cell Signaling: Strategies of chemical signaling, Signaling mediated by intracellular receptors, Extracellular Signaling, Cell-Surface Receptors, G Protein–Coupled Receptors and Their Effectors, Phosphoinositol cycle, Role of Kinases, e.g. MAP Kinase Pathways, Second Messengers, Ca oscillations, Interaction and Regulation of Signaling Pathways, Molecular Mechanisms of Vesicular Traffic, From Plasma Membrane to Nucleus, Bacterial and plant two-component signaling systems, Bacterial Chemotaxis and Modeling.

UNIT III **(8 hours)**

Cell Differentiation and Developmental Biophysics*:* Cellular differentiation,Molecular mechanism of cell differentiation: Role of morphogens, protein kinase C, cytoskeleton, extracellular matrix.

UNIT IV **(5 hours)**

Biophysics of Apoptosis: Relevance of Programmed Cell Death, Necrosis & Apoptosis, Mechanisms of Apoptosis, Role of beta Amyloid, Caspases and Mitochondrial proteins.

Cancer: Tumor Cells and the Onset of Cancer, Proto-Oncogenes and Tumor-Suppressor Genes, Oncogenic Mutations Affecting Cell Proliferation, Mutations Causing Loss of Cell-Cycle Control, Mutations Affecting Genome Stability.

UNIT V **(12 hours)**

Energy production in the cell: Oxidation-reduction reactions, coupled reactions and group transfer.

Bio-Energetics: Gibb's Free Energy, Gibb's Law of Chemical Reactions; Entropy and enthalpy driven reactions, Biological Oxidation: Aerobic Oxidation and Photosynthesis, Oxidation of Glucose and Fatty Acids to CO2; Structure and Properties of Mitochondria, Cytochrome c, Chemiosmotic Coupling, Electron Transport and Oxidative Phosphorylation, Photosynthetic Stages and Light-Absorbing Pigments, Molecular Analysis of Photosystems

Bioenergetics in Health and Diseases: Regulators of mitochondrial metabolism,

Blood-based bioenergetics, Bioenergetic-dependent neurodevelopmental disorders include neural tube closure defects, microcephaly, intellectual disability, autism spectrum disorders

Practical component (30 hours)

Brief account of Cell biology equipment working and their principles ex: Different types of Microscopes, Basic staining techniques

Essential/Recommended readings

Theory:

- **Books:**

Latest editions of following books are recommended:

- Molecular Cell Biology 6th Edition by Harvey Lodish, Arnold Beck and Chris A. Keiser
- Essential Cell Biology, Fourth Edition By Bruce Alberts, Dennis Bray, Karen Hopkin,lexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter

- The Cell, A Molecular Approach – 6th Edition – Geoffrey M. Cooper, Robert E. Hausman – Sinauer Associates, Inc.
- Molecular and Cellular Biophysics, Meyer B Jackson , (Cambridge)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC06: GENETIC ENGINEERING

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		
BP-DSC06: **GENETIC ENGINEERING**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of the course is to teach students various approaches to conducting genetic engineering for biological research applications and in biotechnology industries.
- To make students capable of analyzing, altering, and recombining different types of DNA fragments and sequences.
- To equip students with detailed knowledge of various techniques and tools used in the field of genetic engineering and their application in the generation of products of commercial use in health, agriculture, industrial, and research sectors.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will understand methods to analyze DNA/RNA/proteins.
- Students will understand the basics of gene cloning, the construction of various libraries, and gene identification.
- Students will be able to analyze the gene expression by PCR, hybridization, and sequencing-based techniques.
- Students will be able to use different techniques to engineer proteins for studying the dynamics of protein-protein and protein-DNA interaction and proteome analysis.
- Students will understand the importance and application of genetic engineering technologies in biology and medicine.
- Students will learn about gene editing technologies and their application in gene therapy.

SYLLABUS OF BP-DSC06

Theory component (45 hours)

UNIT I **(5 hours)**

Tools of Genetic Engineering: Impact of genetic engineering in modern society; General molecular tools: restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; Host strains; Basics of cloning: cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing for ligation free cloning; Labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes; Hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.

UNIT II **(9 hours)**

Types of vectors: Plasmids; Bacteriophages; M13mp vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors: insertion and replacement vectors; Cosmids; Artificial chromosome vectors (BACs; YACs); Principles for maximizing gene expression; Expression vectors; pMal; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to enhance soluble expression of heterologous proteins; Mammalian expression and replicating vectors; Yeast vectors; Shuttle vectors; Baculovirus and Pichia vector system; Plant-based vectors: Ti and Ri as vectors.

UNIT III **(9 hours)**

Hybridization techniques and PCR: Radioactive and non-radioactive labeling of nucleic acids and proteins; Southern, northern, western, fluorescence *in situ* hybridization (FISH), and detection of chromosomal abnormalities; Principles of PCR; Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested, reverse-transcription PCR, real-time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR; Cloning of PCR products, T-vectors; Proofreading enzymes; PCR based site-specific mutagenesis; PCR in molecular diagnostics, viral and bacterial detection.

UNIT IV **(6 hours)**

Sequencing and mutagenesis methods: Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; RNA sequencing; Chemical synthesis of oligonucleotides; Mutation detection: SSCP, DGGE, RFLP; Mutagenesis - insertion and deletion mutagenesis, site-directed mutagenesis.

UNIT V **(8 hours)**

Gene manipulation and protein-DNA interaction: Insertion of foreign DNA into host cells: transformation, electroporation, transfection; Construction of libraries: isolation of mRNA and total RNA; Reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; Construction of microarrays: genomic arrays, cDNA arrays and oligo arrays; Protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; Methyl interference assay, chromatin immunoprecipitation; Protein-protein interactions using yeast two-hybrid system; phage display.

UNIT VI **(8 hours)**

Application of Genetic engineering: Gene silencing techniques: siRNA and miRNA construction of shRNA vectors; Gene knockouts and gene therapy; Creation of transgenic plants; Debate over GM crops; Transgenics - gene replacement; Gene targeting; Creation of transgenic and knock-out mice; Disease model; Introduction to genome editing technologies: ZFNs, TALEN, Cre-Lox; Total and conditional gene knockouts; Origins of CRISPR, CRISPR Knockout basics; CRISPR Knockin

(Inserting or Mutating DNA Sequences in the Genome), CRISPR-Based Gene Therapy (Gene editing, Clinical Applications).

Practical component (30 hours)

1. Preparation of buffers, reagents, and media (broth & plates).
2. Preparation of competent cells.
3. Transformation of *E. coli* with standard plasmids and calculation of transformation efficiency.
4. Isolation of vector plasmid from DH5(alpha) strain of *E. coli*.
5. Restriction digestion of vector and insert DNA.
6. Agarose extraction of digested vector and insert DNA.
7. Vector and insert DNA ligation.
8. Transformation of *E. coli* cells with ligation mix and plating on antibiotic-supplemented LB-agar plates.
9. Confirmation of the cloning by colony PCR and restriction mapping.
10. Expression of the recombinant protein in *E. coli* and analysis of the heterologous protein by SDS-PAGE.

Essential/recommended readings

1. Gene Cloning and DNA Analysis: An Introduction, 8th Edition (2020), Wiley-Blackwell
2. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene
3. Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
4. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
5. Selected papers from scientific journals, particularly Nature & Science.
6. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.
7. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

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M.Sc. Biophysics and Bioinformatics

GENERAL ELECTIVE COURSE – BP-DSE04: ENVIRONMENTAL BIOPHYSICS

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		
BP-DSE04: **ENVIRONMENTAL BIOPHYSICS**	**4**	**3**	**1**	**0**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to learn the importance of environment, life and environment
- The student will acquire an increased understanding of impact of human life style on the environment.
- They will know about the historical perspective of environmental disasters.
- The students will know about the control of pollution, medicinal role of plants

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to familiar with environment and its importance to human being.
- Student will understand the correlation of different environmental parameters with living systems and their protection & sustenance.
- Student will be able to learn about biofuels, environmental imbalance and its consequences.
- Student will be able to understand the importance of biodiversity, conservation and various non-renewable energy sources

SYLLABUS OF BP-DSE04

Theory component (45 hours)

UNIT I **(15 hours)**

Acid rain, Photochemical smog- mechanism of formation and ecological effects, chemical involved in ozone layer depletion, Montreal and Kyoto protocol mechanism of global warming and Greenhouse effect.

UNIT II **(15 hours)**

Bhopal Gas tragedy, Chernobyl disaster, biogeochemical cycles, economic value of biodiversity: medicinal plants and their role as therapeutics

UNIT III **(15 hours)**

Conservation of biodiversity: In situ and ex situ conservation, covid-19 pandemic: outbreak, spread and prevention, environmental pollution, Changing Human Behavior to Conserve Biodiversity, Plastics and the Environment

Tutorials component (15 hours)

UNIT I **(15 hours)**

Reaction in atmosphere: Photochemical reactions, acid base reactions, reaction of gases, Air and water pollution control, Non-Renewable Energy Resources, Hazardous Wastes, biofuels, Sustainability in Health Care, Energy Efficiency: What Has Research Delivered in the Last 40 Years?

Essential/recommended readings

Latest editions of following books are recommended:

1. Molles MC (2012) Ecology – Concepts and applications, 6th Edition, Mc Graw Hill
2. Stanley E Manahan; Environmental Chemistry; CRC Press.
3. Roy M. Harrison; Principles of Environmental Chemistry; RSC publishing
4. An Introduction to Environmental Biophysics by Campbell, Gaylon S., Norman, John M. (Springer

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M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE05: BIOPHYSICAL METHODS: FUNDAMENTAL TECHNIQUES

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		
BP-DSE05: **BIOPHYSICAL METHODS: FUNDAMENTAL TECHNIQUES**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Provide students with a foundational understanding of the basic biophysical methods used to study the structure and function of biological macromolecules, particularly proteins and nucleic acids.
- Students would be provided an understanding of the historical development of classical techniques such as spectroscopy, hydrodynamic methods, chromatography and electrophoresis, with an introduction to their principles, applications, and limitations
- The student will be introduced to how these methods are used in modern biological research and biotechnology industry.
- The students will be motivated to analyze and discuss most appropriate methods for exploring varied research problems.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to comprehend and describe the fundamental principles of common biophysical techniques.
- The student will be able to choose and apply biophysical methods to study the structure, function, and interactions of biological molecules.
- The students will be able to design experiments and analyse data from techniques like UV-Vis spectroscopy, circular dichroism (CD), and fluorescence spectroscopy.
- Student will be able to carry out basic biophysical methods experiments in the laboratory.

SYLLABUS OF BP-DSE05

Theory component (45 hours)

UNIT I: Introduction to Biophysical methods (3 hours)

- Overview of biophysical methods and their role in biological research and clinical work
- Basic concepts in physics and chemistry relevant to biophysical methods
- Principles of energy, thermodynamics, and kinetics in biological systems

UNIT II: Hydrodynamic Methods (4 hours)

- Introduction to the hydrodynamic methods and their measurements: Diffusion, Osmosis, Viscosity
- Applications of viscosity measurements in clinical sciences and biotechnology

UNIT III: Spectroscopic Methods (10 hours)

- Introduction to spectroscopic techniques: Absorption, Emission and Scattering of light, Implications of particle and wave nature of light, Quantized energy levels
- Principles of UV-Vis spectroscopy: Beer-Lambert Law and its applications, Quantification of biomolecules (proteins, nucleic acids),
- Principles of fluorescence spectroscopy: Fluorescent probes and dyes, variations of techniques such as Fluorescence quenching and resonance energy transfer (FRET), Fluorescence recovery after photobleaching (FRAP)
- Principles of InfraRed Spectroscopy: absorption or transmission spectra for identifying functional groups in organic compounds and macromolecules
- Circular Dichroism: Basic principles of CD spectroscopy, Applications in monitoring protein folding and stability via study of secondary and tertiary structure

UNIT IV: Chromatographic methods (10 hours)

- Definition of chromatography, Principles of separation science: adsorption, partition, ion exchange, and size exclusion, types of chromatography based on different principles
- Affinity chromatography: principle, method, types and applications in biological research
- Ion exchange chromatography: principle, method, types and applications in biological research
- Size exclusion chromatography: principle, method, types and applications in biological research
- Hydrophobic chromatography: principle, method, types and applications in biological research
- Reverse phase chromatography: principle, method, types and applications in biological research
- Gas chromatography: principles, method, and applications in biological research
- Resurgence and current applications of Thin Layer chromatography, Paper chromatography
- Advances in chromatographic methods: High performance Liquid Chromatography

UNIT V: Electrophoretic Methods (8 hours)

- Principles of Electrophoresis: Polyacrylamide, and Agarose matrix for protein and nucleic acids analysis

- Novel variations in electrophoresis: Native vs. SDS; 2D-Gel electrophoresis, Iso-Electric focussing
- Capillary Electrophoresis: principle, method, and applications in biological context
- Free flow electrophoresis: principle, method, and applications in biological context
- Applications in clinical diagnostics and therapeutic industry

UNIT VI: Centrifugation methods (5 hours)

- The theoretical principles behind centrifugation methods, sedimentation force and coefficient, Svedbergs constant
- Types of centrifugal separations: differential, density gradient,
- Application of centrifugation in biomolecular research: separation of cellular components, proteins, nucleic acids, and organelles.
- Analytical ultracentrifugation: Introduction, principle of sedimentation velocity and sedimentation equilibrium, measurement of molecular weight, shape, and interactions among biomolecules, application in studying protein-protein interactions, protein folding, and conformational changes.

UNIT VII: Optical Microscopy (3 hours)

- Overview of microscopy, Historical development of microscopy and its role in cell biology.
- Principles of light microscopy: resolution, magnification, and contrast.
- Types of light microscopy: bright-field, phase contrast, and differential interference contrast (DIC).
- Applications of light microscopy in studying cellular structures and biomolecular localization.

UNIT VIII: Emergence of combination techniques (2 hours)

- Recent advances in methods involving combination of above techniques

Practical component (30 hours)

UNIT 1: Following experiments would be performed:
1) UV-Vis absorption spectroscopy to measure protein concentration
2) UV-Vis absorption spectroscopy to explore DNA concentration and melting
3) Fluorescence spectroscopy to study effect of pH on protein stability
4) Fluorescence spectroscopy to study effect of temperature on protein stability
5) Fluorescence spectroscopy to study effect of denaturing agents on protein stability
6) Affinity Chromatography: HIS-Tag based purification
7) Ion Exchange chromatography: for protein purification
8) Size exclusion Chromatography: for quaternary structure estimation
9) Circular dichroism study to estimate secondary structure of protein
10) Circular dichroism study to explore conformational changes in protein on heating

Essential/Recommended readings

Theory:

- **Books:**

1) Bengt Nolting (2010). Methods in modern biophysics. Springer.
2) Jay A. Glasel, Murray P. Deutscher (1995). Introduction to Biophysical Methods for Protein and Nucleic Acid Research. Academic Press.

- **Online Resources**:

Websites as discussed in class

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE06: TEXT MINING METHODS IN BIOLOGY

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		
BP-DSE06: TEXT MINING METHODS IN BIOLOGY	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to provide students with the skills to apply text mining methods to biological and biomedical research using freely available online tools and databases.
- Students will learn how to extract biological information, scientific research findings from large corpora of scientific literature and biological databases.
- The students will gain hands-on experience with publicly available data, and apply these methods to generate reviews and hypothesis.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will understand key concepts in text mining and its applications to biology.
- The student will be able to use popular web-based tools and databases (e.g., PubMed, Pubtator, STRING, BioBERT, TextRazor) for text mining.
- The student will be able to extract, analyze, and interpret biological information from scientific literature and other available online sources.
- The student will be able to conduct systematic literature reviews using advanced search tools and implement text mining techniques to answer biological research questions.

SYLLABUS OF BP-DSE06

Theory component (45 hours)

UNIT I: Introduction to Text Mining (6 hours)

- Definition and overview of text mining, Introduction to the types of data in biology (e.g., Scientific literature, clinical data, gene expression data)
- Importance of Text mining in the biological sciences, Advantage and challenges in text mining
- Basic concepts: unstructured vs. structured data, text preprocessing
- Introduction to K-mean clustering, Decision tree, Natural Language processing, K-nearest Neighbour

UNIT II: Biological literature databases (6 hours)

- Introduction to biological literature sources: PubMed, PubMed Central, Google Scholar, Scopus, web of Science
- Structure of scientific literature

UNIT III: Web tools for Text Mining (10 hours)

- Introduction to Web-Based text mining tools: Pubtator, BioBert, Textrazor
- Advantages and limitations of Web-Based text mining tools

UNIT IV: Data Interpretation and Visualization (6 hours)

- Introduction to data visualization
- Types of plots for data visualization: wordcloud, heatmaps, networks graphs and Scattered plots
- Available tools for data visualization: cytoscape, matplotlib, Textalyzer, Infogram

UNIT V: Tools and methods for Literature Review (10 hours)

- Introduction to Scientific literature Analysis tools: LitMaps, Connected Papers, Paperscale, Scite
- Advantages, strengths and Limitation of these tools

UNIT VI: Future of Text Mining (7 hours)

- The role of AI and machine learning in advancing text mining for biology, deep learning and its application to biomedical text
- Future trends in biomedical text mining, including NLP with pre-trained models (e.g., BioBERT, SciBERT

Practical component (30 hours)

UNIT I: Databases/Webservers:

1) Learning to access and extract information from PubMed.
2) Learning to use Pubtator
3) Learning to use BioBert
4) Learning to use and create graphs in Textrazor
5) Learning to use and create networks in Cytoscape
6) Learning to use and create graphs in Infogram

7) Learning to use and create graphs in Textalyzer
8) Accessing and extracting data from Paperscale
9) Analysing data using Scite
10) Extracting literature review data from LitMaps

Essential/Recommended readings

Theory:

- **Books:**
  Research papers and reviews on the topic as discussed in class.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

SKILL BASED COURSE – BP-SB02: SPECIALISED LABORATORY – II: Cell Biology and Bioinformatics

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		
BP-SB02: **SPECIALISED LABORATORY -II : Cell Biology and Bioinformatics**	**2**	**0**	**0**	**2**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this skill enhancement laboratory course is to provide practical skills on basic cell based and computational techniques.
- To acquaint the students with cell culture lab environment, basic lab infrastructure, equipment handling, and safety guidelines.
- To acquaint the students with basics of computational biology by hands-on training.
- To develop skilled manpower equipped with bioinformatics know how.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to maintain basic cell lines under aseptic conditions.
- Students will be able develop stable lines and understand the basis of cell based assays.
- Students will be able extract data from the relevant biological databases.
- Students will be able to analyse data from the relevant biological databases

SYLLABUS OF BP-SB02

Unit I (30 hours)

1. Demonstration of good laboratory practices with reference to Cell and tissue culture.
2. Functioning and calibration of pH meter
3. Brief account of Cell biology equipment working and their principles For ex: Different types of Microscopes, Laminar flow, incubators, autoclave
4. Introduction to sterilization, disinfection, and safety in cell culture laboratory.
5. Preparation of buffers
6. Introduction to various components of Cell culture media for different cell lines.
7. Cell line revival and cryopreservation
8. Cell subculturing
9. Cell counting using hemocytometer
10. Determination of cell viability using trypan blue
11. Cell lysate preparation using mechanical methods
12. Spectrophotometric/colorimetric estimation of total protein in lysate
13. Case study/Group Discussion: data analysis and results

Unit II (30 hours)

1. Retrieval of genomic and transcriptomic NGS reads from public repository, for example NCBI-SRA,
2. Quality control, pre-processing and assembly of transcriptomic reads, determination of differentially expressed genes
3. Discovery of phenotypically important SNPs in a genome.
4. Retrieval of proteomic data from a public repository, determination and differentially expressed proteins and their functional annotation.

Essential/recommended readings

i) Culture of Animal cells 4th Edi by Freshney, R.I.
ii) Animal cell culture- practical approach by Edi. Jhon R.W. Masters ; Oxford
iii) Algorithms for Next-Generation Sequencing (first edition). Wind-Kin Sung ISBN: 978-1466565500
iv) Introduction to computational proteomics (first edition). Golan Yona. ISBN: 978-0367452285

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC07: PHYSIOLOGICAL BIOPHYSICS

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		
BP-DSC07: PHYSIOLOGICAL BIOPHYSICS	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will be able to enumerate the various processes & mechanisms controlling the physiological viability and function
- Students will understand the physical principles involved in physiological function of various organs and their sustainance.
- Students will understand the integration of principles of physiological functioning & sustainance at the whole body level.

Learning Outcomes

The Learning Outcomes of this course are as follows.

- Should be able to design nutrition.
- Should be able to understand blood related disorders and recommend precautions.
- Should understand functioning of healthy muscles and diagnose muscle disorders.
- Should understand the functioning of the heart and recommend its healthy maintenance.
- Should be able to give recommendations for respiratory problems.
- Should understand the biophysical principles of the functioning of the kidney and its maintenance.
- Should understand the role of various hormones in animal & human bodies.

SYLLABUS OF BP-DSC-07

Theory component (45 hours)

UNIT I **(4 hours)**

Levels of structural organization and body systems. Homeostasis, Chemical level of organization, Cellular level of organization

UNIT II **(6 hours)**

Overview of the Digestive System, Phases of Digestion and Nutrition
Composition, function and regulation of salivary, gastric, pancreatic, bile and intestinal juices.
Metabolism of Carbohydrates, Protein, Lipids

UNIT III **(8 hours)**

Biophysics of the circulatory system: Composition and function of blood and lymph, Blood pressure, capillary pressure, Regulation of blood pressure, Role of ionic balance;
Blood groups and Rh factors, Blood coagulation, structure and function of haemoglobin, Sickle-cell anemia, thalassemia and other disorders
Biophysics of Heart: Structure, origin, conduction and regulation of heart beat;
Cardiac cycle; Electrocardiogram; Disorders of the heart; Atherosclerosis, arrhythmias.

UNIT IV **(7 hours)**

Biophysics of Muscle Function: Ultra-structural, chemical and physiological basis of skeletal muscle contraction; Molecular mechanisms in muscle contraction.

UNIT V **(5 hours)**

Biophysics of Respiration: Mechanisms and control of breathing; Transport of oxygen and carbon-di-oxide; Oxygen dissociation curves of haemoglobin and myoglobin, Bohr effect; Chloride shift; Human respiratory disorders.

UNIT VI **(5 hours)**

Structure and Function of the kidney: Physiology of urine formation; Role of kidney in the regulation of water, salt and acid-base balance, renal disorders, remedies; Biophysical perspective of the above.

UNIT VII **(6 hours)**

Integration and Control: The endocrine system, hormones and other signaling molecules, hypothalamus, pituitary, parathyroid, adrenal, pancreas and gonads; Other endocrine elements (pancreatic islets etc.); Local chemical mediators, prostaglandins; Consequences of endocrine malfunction; Biophysical perspective of the above.

UNIT VIII **(4 hours)**

Medical biophysics: Intermolecular Forces (Dipole, Polar and Nonpolar Molecules and Solubilities), Biophysics of Thermoregulation and Heat Exchange, Biophysical Principle for Biochemical Tests, Biomedical Telemetry (Biotelemetry), Patient Monitoring System , Radioactivity and ionizing radiation

Practical component (30 hours)

- To prepare the blood film and identify the blood cells.
- To observe and count the lymphocytes of blood.
- To isolate the lymphocytes from blood
- Effect of hypertonic/ hypotonic/isotonic on RBC membrane.

Essential/Recommended readings

Theory:

- **Books:**

Latest editions of following books are recommended:

i) Biophysics: A Physiological Approach by Professor Patrick F. Dillon (Author)
ii) Physiology, Biophysics, and Biomedical Engineering by Andrew W Wood (Taylor
iii) & Francis)
iv) Textbook of Medical Physiology by Arthur C. Guyton (Elsevier Saunders)
v) Principles of Anatomy and Physiology with Study Guide by Gerard J. Tortora
vi) Medical Biophysics by Judit Fidy

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC08: HIGH-THROUGHPUT BIOLOGY

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		
BP-DSC08: **HIGH-THROUGHPUT BIOLOGY**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- select the appropriate platform for system-level understanding of cellular phenomena
- critically assess the results of a proteomics, genomics and metabolomics experiment
- understand the merits/demerits of a analysis tool employed to analyze the results of proteomics, genomics and metabolomics experiment

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Understanding of quantification and identification of proteins, their post-translational modifications and interactions from mass spectrometry data.
- Knowledge of commonly used technologies and bioinformatics principles for high-throughput genomics analysis.
- Know important biological databases and relevant statistics/ bioinformatics software tools to analyze microarray and NGS transcriptomics data.
- Should evaluate and apply the appropriate experimental design in a given metabolomics research question (including sample processing, choice of methods and analytical strategies).

SYLLABUS OF BP-DSC08

Theory component (45 hours)

UNIT I **(5 hours)**

Mass spectrometry basics; Proteomics bioinformatics basics; Quantitative proteomics; Introduction to data independent acquisition approaches; MS proteomics repositories; Introduction to proteogenomics; Protein interaction data resources. Current developments and recent progress.

UNIT II **(5 hours)**

Advantages and disadvantages of different generations of DNA sequencers. Application-specific changes in the sample preparation methods for DNASeq, RNASeq, ChIPSeq and Metagenomics, single cell genomics.

UNIT III **(5 hours)**

Overview of NGS data formats – FASTQ, Single-end, Paired-end, Mate-pair. Measure of sequence read quality – Phred score; Read pre-processing and quality check assessment tools – FASTQC and Trimmomatic respectively.

UNIT IV **(5 hours)**

Algorithm of NGS read assembly, contigs, scaffolds, assembly quality assessment using N50, total length, no. of contigs/scaffolds; Overview of read mapping, tools for read mapping – BWA, Bowtie, and their output file formats – BAM, SAM, SAMtools; assessment of quality of read alignment; SNP and Variant Calling - Personalized medicine; variant visualisation tools – IGV.

UNIT V **(5 hours)**

Introduction to metagenomics, Basic methods and techniques for metagenomics study, Quality control, Community taxonomic profiling, Community diversity, metagenomic reads assembly, Taxonomic binning, metatranscriptomics, Applications of metagenomics: metagenomics of the human microbiome, bio-prospecting novel genes, metagenomics for industrial bioproducts, metagenomics for bioremediation, plant-microbe interactions, metagenomics and ecosystems biology;

UNIT VI **(5 hours)**

Different methods of transcriptomic study; Quality assessment and QC of RNAseq read sequence data; Transcript identification, *de-novo* vs referenced-based transcriptome assembly; Differential gene expression analysis, Alternative splicing analysis, Visualization, Functional profiling of differentially expressed genes; Single-cell RNA-seq, spatial transcriptomics

UNIT VII **(5 hours)**

Tools and data-format, Quality-control of data, statistical tests of association for binary and quantitative traits, Binary outcome measure, Quantitative outcome measure, Correction for multiple testing, polygenic risk score analysis

UNIT VIII **(5 hours)**

Metabolomics**:** Introduction of different tools for metabolic profiling; Different tools used for metabolic data and database analysis e.g. KEGG, BioCyc, MetExplore and Cytoscape;Current developments and recent progress.

UNIT IX **(5 hours)**

Integration of omics data and system biology in precision medicine: Introduction to Precision Medicine; Methodologies in Precision Medicine, Integration of High-throughput

and System Biology for Developing Novel Approaches of Personalized Medicines, Implications of Personalized Medicines on Global Health Policies.

Practical component (30 hours)

- Retrieving NGS data from data sources - SRA toolkit; Aspera connect.
- Assessment of read sequence quality using FASTQC, pre-processing of reads using Trimmomatic, Assembly of reads into genome, Determination of assembly quality and functional annotation of genes

Essential/recommended readings

Theory:

1. Next-Generation DNA Sequencing Informatics (second edition). Stuart M. Brown (Editor). ISBN 978-1-621821-23-6
2. Methods in Molecular Biology (2649)- Metagenomic data analysis. Suparna Mitra (editor). ISBN: 978-1-0716-3071-6
3. Algorithms for Next-Generation Sequencing (first edition). Wind-Kin Sung ISBN: 978-1466565500
4. Introduction to computational proteomics (first edition). Golan Yona. ISBN: 978-0367452285

Practical:

1. Bioinformatics and Functional Genomics (third edition). Jonathan Pevsner. ISBN: 978-1-118-58176-6
2. Proteomics Data Mining - Advanced Computational Methods for Bioengineers: With R and Bioconductor (first edition). Jamie Flux. ISBN: 979-8300370244

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

GENERAL ELECTIVE COURSE – BP-DSE07: BIOPHYSICAL METHODS: FRONTIERS

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		
BP-DSE07: **BIOPHYSICAL METHODS: FRONTIERS**	**4**	**3**	**1**	**0**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to delve deeper into biophysical methods and their applications in cutting-edge biological research. It emphasizes specialized and more sophisticated analytical techniques.
- Students would be provided an understanding of the historical development of these techniques and their current applications, advantages and limitation.
- The student will be introduced to how these methods are used in modern biological research and biotechnology industry.
- The focus would be on data interpretation using these methods. The students will be motivated to analyze and discuss most appropriate methods for tackling unique research problems.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to apply advanced biophysical techniques for the study of complex biomolecules.
- The student will be able to understand the principles and applications of these methods.
- The students will be able to design experiments and analyse data for structural and functional analysis of biomolecular interactions.
- Student will be able to trace the history of development of these advanced techniques, making them aware of the advantages of the interdisciplinary approaches for solving complex biological problems. They will understand the current trends in biophysics and contribute to research in this field.

SYLLABUS OF BP-DSE-07

Theory component (45 hours)

UNIT I: Introduction to advanced Biophysical methods (3 hours)

- Overview of advanced biophysical methods and their development
- Path to discovery and current utility in biological research

UNIT II: Macromolecular Structure determination methods (8 hours)

- X-ray crystallography: History and development of X-ray crystallography, Principles of X-ray diffraction, Methods and Challenges in crystallizing biomolecules, Overview of data collection and refinement, Phase estimation through methods like Molecular replacement, Isomorphous replacement (MIR, SIR), Anamolous Dispersion (MAD, SAD), creating electron density maps, structure validation and model fitting. Introduction to Synchrotrons sources. Cryo-crystallography, Advancements example SAXS.
- Nuclear Magnetic Resonance (NMR): Principles of 1D, 2D, 3D spectroscopy, chemical shifts and spin-spin interaction, Multidimensional NMR for protein and nucleic acid structure, Analysis of protein-ligand complexes and molecular movements.

UNIT III: Advances in Microscopic methods (8 hours)

- Introduction to Electron Microscopy: Basics of cryo-EM, sample preparation, imaging, and data collection, Types (SEM, TEM), advantages and limitations of each, Combining cryo-EM and X-ray crystallography for structural determination,
- Introduction to Fluorescence microscopy: Principles, Fluorescent dyes, GFP constructs, design of experiments to study conformational changes in a model protein or nucleic acids, Monitoring binding interactions of a ligand to a protein.
- Atomic Force microscopy: Principles, topography, force spectroscopy, and imaging at the molecular level for measuring mechanical properties of biomolecules (e.g., protein-ligand interactions, DNA stretching), Force-distance curves and the study of biomolecular interactions under controlled conditions, imaging of single-molecule conformations and surface-bound biomolecules.

UNIT IV: Advances in Spectroscopic Methods (10 hours)

- Introduction to Dynamic Light scattering (DLS): Basic principles of light scattering, measuring protein size, conformational changes and heterogeneity of solution, applications in studying protein aggregation and stability
- Time resolved Spectroscopy: Overview of time-resolved absorption, fluorescence, CD, Raman techniques, Studying protein dynamics and conformational changes, Applications in enzyme kinetics, molecular mechanisms, inhibitory mechanism (competitive, non-competitive, or uncompetitive).
- Advanced Flourscence methods: Fluorescence lifetime imaging microscopy (FLIM) and applications in protein-protein interactions.
- Nanoparticle tracking Analysis (NTA): principle, method, and applications in biological context, Applications in clinical diagnostics and therapeutic industry
- Introduction to Ultra-fast spectroscopic methods

UNIT V: Advances in Protein-ligand interaction studies (8 hours)

- Introduction to biophysical methods to study small molecule binding and screening, with focus in drug-protein interactions
- Surface Plasmon Resonance (SPR): Basics of SPR and its applications in studying biomolecular interactions, Interpretation of SPR sensograms, Measuring binding kinetics between proteins and ligands,
- Bio-Layer Inferometry (BLI): Overview, principle, method and working mechanism (light interference and reflection), types of sensors, and applications in biological research, use in combination with other

techniques (e.g., mass spectrometry, SPR), High-throughput BLI for screening applications, and Temperature-dependent studies.

- Iso-thermal Calorimetry (ITC): Overview, principle and historical development, comparison and advantages with other biophysical techniques (e.g., surface plasmon resonance, fluorescence). Applications in studying protein-ligand binding, protein-protein interactions, and enzyme kinetics.

UNIT VI: Methods in Single molecule analysis (8 hours)

- Introduction to single molecule techniques: Overview, Historical development, Impact on molecular biology, Advantages over ensemble-averaged techniques, Applications in studying biomolecular dynamics, folding, and interactions.
- Single-Molecule Fluorescence Spectroscopy (SmFRET): Overview and principle of Single-molecule fluorescence microscopy for monitoring conformational changes and dynamic processes in real-time, Experimental setup and data interpretation in single-molecule fluorescence
- Optical Tweezers: Principles of optical tweezers, trapping and manipulating single molecules using laser beams, Measurement of force and displacement in molecular systems, Applications in studying protein unfolding, DNA/RNA mechanics, and molecular motors, Analysis of force-extension curves and thermodynamic parameters.

Tutorial component (15 hours)

UNIT I: Case studies related to each technique in published research papers will be discussed:

1) Understanding crystallographic data deposited in PDB and in papers, with special emphasis on case studies in protein-ligand interactions
2) Understanding data of AFM study of DNA-protein interactions in gene regulation.
3) Understanding the data and interpretation for cryo-EM in determining structures of large macromolecular complexes, and membrane proteins.
4) Understanding and analysing DLS data for interpreting heterogeneity of the sample.
5) Understanding and analysing NTA data for interpreting particles size and interactions.
6) Understanding the SPR data to analyse binding kinetics of protein-ligand interactions.
7) Understanding the BLI data to analyse binding kinetics of protein-ligand interactions.
8) Analyzing the raw data of ITC to determine thermodynamic parameters such as binding affinity (Kd), stoichiometry (n), enthalpy (ΔH), and entropy (ΔS).
9) Designing experiments for smFRET
10) Understanding use of optical tweezers to study the mechanical properties of DNA or protein folding

Essential/Recommended readings

Theory:

- **Books:**

1) Gale Rhodes (2006). Crystallography made crystal clear. Complimentary Science Series.
2) Research papers and instrument manuals

- **Online Resources**:
  Instrument Websites as discussed in class

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M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE08: BIOMOLECULAR INTERACTIONS

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		
BP-DSE08: **BIOMOLECULAR INTERACTIONS**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to introduce the students to the essentials of Biomolecular interactions.
- The student will understand the structure of various biomolecules involved in various pathways of biological systems.
- They will be understand the interaction involve among biomolecules and its significance.
- The students will be delivered the knowledge about protein folding, denaturation and involvement of biomacromolecules among various pathological disorder

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to evaluate the structure of amino acid and protein.
- Student will be able to correlate the role of biomolecular interactions among biological pathways.
- Student will be able to comprehend how biomolecules folded and unfolded under various environmental conditions.
- Student will be able to study different processes involve the biomolecular interactions.
- Student will be able to describe the different pathological disorders involving biomolecules.
- Student will be able to learn the therapeutics involved in disorders

SYLLABUS OF BP-DSE08

Theory component (45 hours)

UNIT I **(20 hours)**

Journey from amino acid to protein: Introduction to amino acids, partial double bond character of peptide bond; structural levels of protein, posttranslational modifications of protein, techniques to study secondary tertiary and quaternary structure of protein, Greek key motifs, leucine zippers, determination of protein structure- Sequence determination of proteins, N- and C-terminal amino acid analysis; Edman's degradation: classical and automated procedures, DNA sequencing by Maxam and Gilbert method, Sanger's method.

UNIT II **(10 hours)**

Role of Cooperativity in biomolecular interactions: cooperative and non-cooperative (Sigmoidal) binding of ligands, Hill equation, Sequential and concerted model for cooperative binding. biomolecular denaturation process, study of molecules involved in folding pathway of proteins, Practical aspects of binding analyses.

UNIT III **(5 hours)**

Biomolecular interactions of Protein/DNA/lipid/carbohydrate/drugs

UNIT IV **(10 hours)**

Amyloid and functions: types of amyloids, techniques to study amyloids, factors affecting protein aggregation, aggregation kinetics and therapeutic strategies to combat neurological disorders, pathological disorders induced by protein aggregates

Practical component (30 hours)

UNIT I **(20 hours)**

Molten globule study of proteins (eg. Lysozyme), electrophoresis of proteins, molecular docking study of protein-ligand interactions, Abosption spectrum of protein and DNA.

UNIT II **(10 hours)**

Secondary and tertiary structure study of protein, aggregation kinetics study of proteins, various assays to study aggregates

Essential/recommended readings

Theory:

1. Lehninger; Principles of Biochemistry; W.H Freeman and Company;
2. J.M. Berg, J.L. Tymoczko and L. Stryer; Biochemistry; W.H. Freeman and Company.
3. D. Whitford; Proteins, Structure and Function; John Wiley & Sons Ltd.

Practical:

1. David Eliezer; Protein Amyloid Aggregation: Methods and Protocols; Humana Press.
2. Freifelder, David Michael; Physical biochemistry : applications to biochemistry and molecular biology; W.H. Freeman and Company.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE09: INFECTION AND IMMUNITY

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		
BP-DSE09: **INFECTION AND IMMUNITY**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of the course is to make students understand the basic concepts of infection establishment and immune activation by the host in response to such an insult.
- To make students understand the basic concepts of innate and adaptive immunity, host-pathogen interaction, and the concept of prevention of infections through vaccines.
- To make students learn the techniques used to perform research in the field of basic immunology, immunotechnology, and immunodiagnostics.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will understand the fundamental concepts of the human immune system and basic immunology.
- Students will be able to differentiate innate and adaptive immune systems, broadly describe how the immune systems mature in the host, and how they function in protecting the host from infections.
- Students will be able to describe the basic structures and functions of bacteria, viruses, and parasites and describe pathogenic mechanisms used by them that are important in the interaction with humans.
- Students will learn to use the information acquired during the course to hypothesize how the immune system can be used to fight pathogenic microorganisms and how antigens of pathogenic origin can be used to elicit a protective immune response against the pathogen.
- Students will become acquainted with the immunology lab techniques and immunoinformatic tools and will be able to use this knowledge for designing immunotherapeutic molecules.

SYLLABUS OF BP-DSE09

Theory component (45 hours)

UNIT I **(5 hours)**

Introduction to infectious diseases: Definition of infectious diseases; Symptoms and signs of infection; Acute and chronic conditions; Microbial pathogens – bacteria (intra and extracellular), viruses, fungi, parasites (worms, helminths), and non-microbial pathogen – prions; Direct and indirect person-person transmission; Animal-human transmission; Resolution of infections; Mechanisms of infection, cells and their relationship to pathogens; Nomenclature of pathogens; Emerging infectious diseases.

UNIT II **(8 hours)**

Historic perspectives and introduction to immunology: History and scope of immunology; Types of Immunity – innate immunity, acquired immunity- natural, artificial, active and passive immunity; Nature of antigens, immunogenicity, antigenicity, epitopes; PAMPs, DAMPs; PRRs-toll like receptors, acute phase proteins; Functions of cells of myeloid and lymphoid lineage- granulocytes, dendritic cells, macrophages, T and B lymphocytes; Inflammatory response; Pathways of complement activation and its regulation, Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility; Organs of immune system, primary and secondary lymphoid organs.

UNIT III **(10 hours)**

Humoral and cell-mediated immunity: Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Basis of self & non-self discrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell subsets; Cell-mediated immune responses, ADCC; Cytokines: properties, receptors and therapeutic uses; Antigen processing and presentation – endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation; Hapten-carrier system.

UNIT IV **(8 hours)**

Clinical immunology: Immunity to infection – bacteria, viral, fungal and parasitic infections (with examples from each group); Hypersensitivity: Type I-IV; Autoimmunity; Types of autoimmune diseases; Mechanism and role of $CD4^+$ T cells; MHC and TCR in autoimmunity; Treatment of autoimmune diseases; Transplantation – immunological basis of graft rejection; Clinical transplantation and immunosuppressive therapy; Tumor immunology – tumor antigens, immune response to tumors and tumor evasion of the immune system; Cancer immunotherapy; Immunodeficiency – primary immunodeficiencies, acquired or secondary immunodeficiencies; Autoimmune disorder; Anaphylactic shock; Immunosenescence; Immune exhaustion in chronic viral infection; Immune tolerance; NK cells in chronic viral infection and malignancy.

UNIT V **(8 hours)**

Immunological Techniques and Immunodiagnostics: Precipitation, agglutination and complement-mediated immune reactions; Advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, biosensor assays for assessing ligand – receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell

cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knockouts; Immunodiagnostics based on precipitation, agglutination, haemagglutination, complement fixation test (CFT), labelled assays and *in vivo* reactions.

UNIT VI **(6 hours)**

Vaccinology: Active and passive immunization; Live, killed, attenuated, subunit vaccines; Vaccine technology: role and properties of adjuvants, recombinant DNA and protein-based vaccines, plant-based vaccines; Reverse vaccinology; Peptide vaccines; Conjugate vaccines; Antibody genes and antibody engineering – generation of monoclonal antibodies, hybrid monoclonal antibodies; Catalytic antibodies and generation of immunoglobulin gene libraries; Idiotypic vaccines and marker vaccines; Viral-like particles (VLPs); Dendritic cell based vaccines; Vaccine against cancer; T cell-based vaccine; Edible vaccine and therapeutic vaccine.

Practical component (30 hours)

1. Primary protein structure prediction of antigenic protein.
2. Prediction of antigenicity of antigenic proteins.
3. Prediction of allergic nature of antigenic proteins.
4. Prediction of physiochemical properties of antigenic proteins.
5. Prediction of secondary structure of antigenic protein.
6. Prediction of domains and important sites in antigenic protein.
7. Continuous and discontinuous B-cell epitope prediction.
8. Prediction of immunogenic regions in antigenic protein.
9. Prediction of glycoprotein antigen epitopes.
10. Cytotoxic T cell epitope prediction.
11. MHC class I and II prediction.
12. T cell epitopes processing prediction.
13. T cell epitopes Immunogenicity prediction.
14. Automated and alignment-based antigen modelling.
15. Antibody modelling.
16. Antigen-Antibody Docking.
17. Demonstration of antigen-antibody interaction by ELISA.

Essential/recommended readings

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology:the Immune System in Health and Disease. USA: Garland Science Pub.
2. Punt, J., Stranford, S., Jones, P., Owen, J. (2018) Kuby's Immunology, W. H. Freeman, New York.
3. Murphy, K. and Weaver, C. (2016) Janeway' s Immunobiology, Garland Science, New York.
4. Delves, P.J., Martin, S.J., Burton, D.R., Roitt, I.M. (2017) Roitt's Essential.
5. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.
6. Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.
7. Vaccinology: Principles and Practice, by Editors: W. John W. Morrow, Nadeem A. Sheikh, Clint S. Schmidt, D. Huw Davies; Wiley Blackwell, 2012.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE10: PROTEIN AGGREGATION, MISFOLDING AND DISORDERS

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		
BP-DSE10: **PROTEIN AGGREGATION, MISFOLDING AND DISORDERS**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to deliver the students knowledge about why protein misfold and disorders related to misfolding of protein and preventive strategies.
- The student will understand formation of aggregates.
- They will be understand the difference between aggregates structures and level of toxicity.
- The students will be delivered the knowledge about mechanism of aggregation and kinetic pathways of aggregation
- The students will be motivated to learn protein misfolding disorders.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to characterize the protein aggregates.
- Student will be able to analyse the assembly process involve in the protein misfolding.
- Student will be able to learn about factors responsible for the protein aggregation.
- Student will be able to study the various methods and protocols involve in the study of protein misfolding and also learn about the diagnostic and therapeutic against disorders

SYLLABUS OF BP-DSE10

Theory component (45 hours)

UNIT I **(20 hours)**

Protein aggregation and oligomerisation, types of aggregates, toxicity of aggregates and oligomers, Factors responsible for protein aggregation: pH, Temperature; Co-solvent; shear effect; mutation etc. ubiquitin-proteasome degradation

UNIT II **(10 hours)**

Mechanism of protein aggregation, characterization of protein aggregates, kinetics of protein aggregation

UNIT III **(5 hours)**

Functional amyloids, Principles of protein misfolding: oxidative stress, role of molecular chaperons, kinetic models of protein misfolding.

UNIT IV **(10 hours)**

Protein misfolding disorders: Alzheimer disease, Parkinson's disease, Prion disease, hutington disease, systemic amyloidosis, cystic fibrosis, gaucher disese, cataract etc. methods and protocol to study protein misfolding and aggregates, Diagnosis and therapeutics strategies

Practical component (30 hours)

UNIT I **(20 hours)**

Formation of aggregates by using different protein and factors:
A. Thermally induced aggregation of bovine serum albumin
B. pH and surfactant induced aggregation of lysozyme
C. effect of mechanical stress on aggregation rate of protein

UNIT II **(10 hours)**

Characterization of aggregates: ThT dye binding assay, Congo red dye binding assay, hydrophobicity measurement by using 8-Anilino-1-naphthalenesulfonic acid (ANS) as an extrinsic fluorophore.

Essential/recommended readings

Theory:

1. Marina ramirez-alvarado, jeffery w. Kelly, christopher m. Dobson; protein misfolding diseases: Current and Emerging Principles and Therapies; John Wiley & Sons Ltd
2. Cláudio M. Gomes; Protein Misfolding Diseases: Methods and Protocols; Humana Press.
3. David Eliezer; Protein Amyloid Aggregation: Methods and Protocols; Humana Press.6. Wilson And Walker; Principles And Techniques Of Biochemistry And Molecular Biology; CAMBRIDGE UNIVERSITY PRESS

Practical:

1. Biophysics by W.HoppeW. Lohmann, H. Markl, H. Ziegler (Springer)
2. Holger Gohlke; Protein-Ligand Interactions; Willey VCH.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

SKILL BASED COURSE – BP-SB03: SPECIALISED LABORATORY – III: Protein Chemistry

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		
BP-SB03: **SPECIALISED LABORATORY – III: Protein Chemistry**	**2**	**0**	**0**	**2**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this skill enhancement laboratory course is to provide practical skills on basic microbiological techniques.
- To expose students to the microbiology lab environment, basic lab infrastructure, basic equipment handling, and safety guidelines.
- To develop skilled manpower capable of handling basic lab strains of bacteria e.g. *E. coli,* for future molecular biology and genetic engineering experiments.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- To students will be able to isolate, characterize and identify common bacterial organisms.
- Students will be able to calculate/determine the bacterial load of different samples.
- Students will be able to perform antimicrobial sensitivity tests.
- Students will learn about preserving bacterial cultures of short and prolonged durations.

SYLLABUS OF BP-SB03

Practical component (60 hours)

Unit I

1. Ammonium Sulphate precipitation of protein.
2. Turbidity measurement of lysozyme by UV-Vis absorption spectroscopy.
3. Rayleigh scattering measurement of lysozyme by Fluorescence spectroscopy.
4. Demonstration of dialysis of proteins
5. Demonstration of concentrating protein through centrifugation
6. Scattering correction experiment to validate the concentration estimation of protein by UV-Vis spectroscopy
7. Bacterial cell lysis by sonication
8. Estimation of protein concentration by colorimetric methods
9. Agarose Gel Electrophoresis of nucleic acids
10. SDS-PAGE of proteins
11. Case study & Group Discussion: Design of project proposals using techniques studied.

Essential/recommended readings

1. Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company.
2. Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins and Lyne's Microbiological Methods (8th ed.). Arnolds.
3. Tille, P. M., & Forbes, B. A. Bailey & Scott's Diagnostic Microbiology.
4. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

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M.Sc. Biophysics and Bioinformatics

RESEARCH TRACK COURSE– BP-RT01: ADVANCED RESEARCH METHODOLOGY

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		
BP-RT01: **ADVANCED RESEARCH METHODOLOGY**	**2**	**2**	**0**	**0**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide students with skills on basic research aptitude.
- To provide students with skills to formulate a research problem citing its importance and design suitable methods
- To make students aware of pitfalls of plagiarism
- To make students aware of different ways of protecting intellectual property.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- To students will be able to identify research gaps and formulate a research problem explaining its significance.
- Students will develop the ability to detect and avoid plagiarism.
- Students will be aware of methods to protect their intellectual rights and research.

SYLLABUS OF BP-RT01

Theory component (30 hours)

Unit 1: Research Question Formulation (10 hours)
What is a research problem? Philosophy and meaning of research; Identification and definition of research problem; Survey of available literature and bibliographical research; Search and verification of facts, the analysis of evidence; truth & causation; sources of prejudice and bias; Formulation of Research problem

Unit 2: Plagiarism in research (7 hours)
Definition and types of plagiarism; What is and what is not plagiarism? Methods to detect plagiarism, Available tools and software to detect plagiarism. How to avoid plagiarism.

Unit 3: Intellectual Property Right (7 hours)
Concepts and types of intellectual property; Who needs intellectual property protection? Objectives and differences among patent, copyright and trademark; Procedure for obtaining a patent; Protection against infringement; Indian and global institutions involved in IPR; Issues in patentability; Search engines for patent; IP for Bioinformatics; Types of Bioinformatics Patents. IPR in Ayurveda and Social Sciences.

Unit 4: Case studies (6 hours)
Discussing progression from basic science to applied science to patents, entrepreneurship and business.

Essential/recommended readings

1. William Trochim, James P. Donnelly, Kanika Arora (2023) Research Methods: The Essential Knowledge Base, Cengage
2. Deborah E Bouchoux, Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets, Cengage

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

Research Track – BP-RT02: TOOLS FOR RESEARCH

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		
BP-RT02: **TOOLS FOR RESEARCH**	**2**	**2**	**0**	**0**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- To make students understand the philosophy of conducting research within the boundaries of ethical principles and develop a sense of research integrity.
- To make students aware of general safety guidelines while working in lab, toxicity of chemicals and level of hazard.
- To make students aware of ways to organize computational resources

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students will become aware of various forms of malpractice and unethical conduct in the research and publishing arena.
- Students will develop an understanding of ethical conduct in the fields of scientific research and publishing scientific data.
- Students will develop the ability to handle the equipment, chemical, glass wares and will be able to risk assessment and control.

SYLLABUS OF BP-RT02

Theory Component (30 hours)

Unit 1: Research and publication ethics (10 hours)

Ethics: definition, moral philosophy; Research ethics: Intellectual honesty and research integrity; Scientific misconduct: Falsification, fabrication; Redundant publications: Duplicate and overlapping publications; Institutional ethical bodies regulating research on – animals, human subjects, and development of genetically modified – microorganisms, animals and plants; Publication ethics: definition, importance; Best practices/standards setting initiatives and guidelines: COPE, WAME, etc.; Conflicts of interest; Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types; Violation of publication ethics, authorship and contributions; Identification of publication misconduct, complaints and appeals; Predatory publisher and journals.

Unit 2: Standard Operating Protocol of Bioinformatics Lab (4 hours)

Need and usage of Standard Operating Protocol in a Bioinformatics Lab, Version control of Software, Scripts/pipelines, operating system

Unit 3: Good lab practices (10 hours)

General laboratory safety: prior to entering to laboratory, during laboratory work, use of fume cupboard, use of safety cabinets, prior to leave the laboratory, laboratory hazards: glassware; chemicals, vacuum systems, cryogenic liquids, gas cylinders, other laboratory equipment Risk assessment and control, disposal of hazardous chemicals, storage guidelines, first aid and emergency.

Unit 4: Case studies (6 hours)

Discussion on Ethics in clinical trials, discussion of case studies of paper retraction.

Essential/recommended readings

1. Nicholas H. Steneck. Introduction to the Responsible Conduct of Research. Office of Research Integrity. 2007. Available at: https://ori.hhs.gov/sites/default/files/rcrintro.pdf.
2. The Student's Guide to Research Ethics By Paul Oliver Open University Press, 2003.
3. Responsible Conduct of Research By Adil E. Shamoo; David B. Resnik Oxford, University Press, 2003.
4. Ethics in Science Education, Research and Governance Edited by Kambadur Muralidhar, Amit Ghosh Ashok Kumar Singhvi. Indian National Science Academy, 2019. ISBN:978-81-939482-1-7.
5. Jürg P. Seiler, Good Laboratory Practice: the Why and the How, Springer
6. Michener, W.K. (2015) 'Ten Simple Rules for Creating a Good Data Management Plan', PLoS Computational Biology, 11(10), pp. 1–9. (https://doi.org/10.1371/journal.pcbi.1004525).
7. Noble, W.S. (2009) 'A quick guide to organizing computational biology projects', PLoS Computational Biology, 5(7), pp. 1–5. (https://doi.org/10.1371/journal.pcbi.1000424).
8. Sandve, G.K. et al. (2013) 'Ten Simple Rules for Reproducible Computational Research', PLoS Computational Biology, 9(10), pp. 1–4. (https://doi.org/10.1371/journal.pcbi.1003285).
9. Way, G.P. et al. (2021) 'A field guide to cultivating computational biology', PLoS Biology, 19(10), pp. 1–14. (https://doi.org/10.1371/journal.pbio.3001419).
10. Ziemann, M., Poulain, P. and Bora, A. (2023b) 'The five pillars of computational reproducibility: bioinformatics and beyond', Briefings in Bioinformatics, 24(6), pp. 1–13. (https://doi.org/10.1093/bib/bbad375).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC09: CELLULAR AND MOLECULAR NEUROPHYSIOLOGY

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		
BP-DSC09: **CELLULAR AND MOLECULAR NEUROPHYSIOLOGY**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

● Students will be able understand the physical principles involved in functioning of the cell & organelle membranes, ion channels, receptors & cell signaling.

● Students will be able to understand the biophysical basis of functioning of neurons & other brain cells, their electrical behavior & communication mechanism.

● Students will be able to understand the biophysics of perception, cognition & memory formation and the related neuronal disorders.

Learning Outcomes

The Learning Outcomes of this course are as follows.

- Should achieve conceptual understanding of the structure & function of biological membranes including ion channels, receptors & other components.
- Should understand the functioning of the nervous system, electrical behavior of neurons & other brain cells.
- Should be able to make a comparison between the functioning of the natural brain & artificial (computer) brain.
- Should understand the biophysical principle of learning & memory.
- Should understand newer mechanisms of learning.

SYLLABUS OF BP-DSC09

Theory component (45 hours)

Unit I **(8 hours)**

Overview of the Nervous System: Introduction to neurons; The Neuron Doctrine; Components and classification of neurons; Types of neurons; Cytology of neurons; Dendrites structure and function; Axons structure and functional aspects; Ultrastructure; Myelination and synapses. impregnation method; Structure and function of glial cells; Different types of glial cells: astrocytes, oligo dendrocytes and Schwann cells; Overview of glial and neuronal relationship in the CNS; Importance of astrocytes in glutamate metabolism and blood brain barrier; Microglial phenotypes; Glial –neuronal interplay in the CNS; Principles of fixation and staining of nervous tissue; Methods of tissue processing for microtomy and cryotomy.

Unit II **(12 hours)**

Biophysical basis of Neurophysiology : **Electrical behavior of the biological membrane**: Model membranes; Biological membranes and Dynamics; Membrane Capacitance; Transport across cell and organelle membranes; Ion Channels; Experimental methods to study Ion Channels.

Electrical properties of excitable membranes: Membrane conductance, linear and nonlinear membrane, ionic conductance, current voltage relations; Ion movement in excitable cells: Physical laws, Nernst-Planck Equation, active transport of ions, movement of ions across biological membranes; Membrane potential and role of sodium and potassium pumps

Sensory Receptors and perception

Unit III **(8 hours)**

Neural Signals Physicochemical principles; Resting potential; Action Potential; Membrane theory of action potential; Hodgkin Huxley's (HH) model

Unit IV **(10 hours)**

Synaptic transmission & Neurotransmission Synaptic vesicles; Principles of synaptic transmission: Electrical and chemical synapses; Calcium hypothesis: Control of transmitter release; Synthesis and trafficking of neuronal proteins. Synaptic transmission at nerve-muscle synapses; Synaptic transmission at central synapses; Ligand gated channels; Second messengers and synaptic transmission. Sodium/ potassium pump – Role of calcium. Chemical transmission

Unit V **(7 hours)**

Neurotransmitters & Neuromuscular Coordination Neurotransmitters – types, synthesis and secretion of neurotransmitters, Receptors–adrenergic receptors and cholinergic receptors. Regulation of transmission, Neurotoxins. Forces involved in ligand – receptor interaction; neuromuscular transmission, reflex action and reflex arc. Regulation of body temperature. Interaction between sense organs and neurons. Artificial neurons; Neural Basis of Cognition and Behavior, Prediction of membrane protein types from sequences, voltage-sensing elements in any membrane protein.

Practical component (30 hours)

- Basic concepts of microscopy, stereology and image analysis; Principles and applications of confocal microscopy
- Study of the nerve cell: cresyl violet staining
- Study of permanent slides
- Acquisition of data for various physiological parameters using various computational data acquisition system

Essential/Recommended readings

Theory:

- **Books:**

Latest editions of following books are recommended:

i. Neuroscience: A Mathematical Primer by Scott, A. (Springer)
ii. Cognitive Neuroscience: The Biology of the Mind by Gazzaniga, M.S. et al. (W.W.Norton & Co)
iii. Principles of Neural Science by Eric R Kandel et al, (McGraw Hill).
iv. Membrane Biophysics by Mohammad Ashrafuzzaman, Jack A. Tuszynski, (Springer Science & Business Media)
xi. The Structure of Biological Membranes by Philip L. Yeagle, (CRC Press).
xv. Methods in Membrane Lipids by Alex DoPico (Humana Press)

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M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSC10: MOLECULAR BIOPHYSICS

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		
BP-DSC10: MOLECULAR BIOPHYSICS	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Student will understand the chemical structure of various macromolecules involved in propagation of life.
- Student will comprehend the influence of macromolecular three dimensional structure on their function.
- Student will appreciate the relevance of physics e.g. thermodynamics, kinetics and cooperatively to the function of biological macromolecules.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to appreciate the effect of various forces in shaping the molecular conformation.
- Student will be able to correlate the biomolecular structure to its specific functions.
- Student will be able to comprehend the role of biomolecular conformation to function.
- Student will be able to appreciate the effect of cooperatively in protein/enzyme function

SYLLABUS OF BP-DSC10

Theory component (45 hours)

UNIT I **(15 hours)**

Nature of Chemical bonds: Forces responsible for molecular conformation, e.g. Hydrogen bonds, ionic/electrostatic interactions, Van der Waals interaction, hydrophobic interaction, stereo-chemical factors

Macromolecular Structure

a) Protein Structure: Amino acids, peptide bond, primary, secondary, tertiary and quaternary structure of proteins, motifs and folds, super-secondary structures.

b) Nucleic acid Structure: nucleosides and nucleotides, RNA structure, DNA structure and conformation, polymorphism of DNA

c) Other Biological Polymers: polysaccharides, associations formed among different macromolecular types

UNIT II **(10 hours)**

Parameters defining conformation of a macromolecular chain, strategies for calculating the probable conformational status of a macromolecule, Computer simulation of macromolecular conformation, membrane protein conformation, Supercoiling of bio-macromolecules: Linking, twisting and writhing, topoisomerases

UNIT III **(5 hours)**

Special Bio-Macromolecules: Metalloproteins, nucleoproteins, ribozymes, membrane proteins, chaperons & prions.

UNIT IV **(10 hours)**

Cooperativity in bio-macromolecular interactions: the phenomenon of cooperativity, DNA and protein melting, allosteric enzymes.

UNIT V **(5 hours)**

Non-equilibrium Thermodynamics in Biology: Information and Entropy, Nonequilibrium Processes, Coupling of Fluxes, Coupling of Chemical Reactions, far-from-Equilibrium Molecular Processes

Practical component (30 hours)

UNIT I **(20 hours)**

- Purification of protein by using ion-exchange chromatography
- purity check by SDS-PAGE,
- chemical and pH denaturation of lysozyme

UNIT II **(10 hours)**

- Excitation and emission spectrum of lysozyme,
- Fluorescence quenching experiment of protein-ligand binding

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Essential/recommended readings

Theory:

1. Biophysics - An Introduction by Rodney Cotterill (Wiley)
2. Molecular Biophysics: Structures and Dynamics by Michel Daune (Oxford Univ. Press)
3. The Biophysical Chemistry of Nucleic Acids & Proteins by Thomas E. Creighton (Helvetica Press)
4. The Physical and Chemical Basis of Molecular Biology by Thomas E. Creighton (Helvetica Press)
5. Molecular Biophysics by MV Volkenstein (Academic press)
6. Wilson And Walker; Principles And Techniques Of Biochemistry And Molecular Biology; CAMBRIDGE UNIVERSITY PRESS

Practicals:

1. Biophysics by W.HoppeW. Lohmann, H. Markl, H. Ziegler (Springer)
2. Holger Gohlke; Protein-Ligand Interactions; Willey VCH.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC CORE COURSE – BP-DSE11: COMPUTER-AIDED DRUG-DESIGN

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		
BP-DSE11: **COMPUTER AIDED DRUG-DESIGN**	**4**	**3**	**1**	**0**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Demonstrate an awareness of the current approaches to global drug discovery and their advantages and limitations.
- Demonstrate an understanding of the steps involved in the drug discovery and design process
- Demonstrate the ability to use evidence-based approaches to guide decision-making during the drug discovery and development process.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- Students would be able to describe the process of drug discovery and development
- Students would be able to discuss the challenges faced in each step of the drug discovery process
- Students have gained a basic knowledge of computational methods used in drug discovery
- Students would be able to organise information into a clear report
- A student would be able to demonstrate their ability to work in teams and communicate scientific information effectively

SYLLABUS OF BP-DSE11

Theory component (45 hours)

Unit I **(2 hours)**

Types of Drug Design: Rational drug design vs. traditional drug discovery, Structure-based drug design, Ligand-based drug design, Fragment-based drug design; **Rational of Selection of Drug Design:** Protein structure and function, Enzyme inhibitors and receptor-ligand interactions, Types of targets (enzymes, receptors, ion channels, transporters).

Unit II **(4 hours)**

Introduction to Molecular Modelling: Definition and types of molecular modelling, Computational chemistry principles, Molecular dynamics simulations, Quantum mechanics vs. molecular mechanics; **Molecular Representation:** Atoms, bonds, molecules, and molecular graphs, D vs. 3D structures, Representation of biomolecules (proteins, nucleic acids, lipids), Conformational analysis and torsional degrees of freedom.

Unit III **(4 hours)**

Protein Structure Classification: Primary, secondary, tertiary, and quaternary structures, Protein folding and stability; **Protein Databases and Tools:** Protein Data Bank (PDB), PDB2PQR, ALPHA-FOLD for homology modelling; **Protein-Ligand Interactions:** Non-covalent interactions (hydrogen bonding, van der Waals, electrostatics), Binding site analysis and identification; **Protein Flexibility and Conformational Changes:** Importance of flexibility in drug design, Techniques for dealing with protein flexibility (e.g., induced fit docking, flexible docking).

Unit IV **(10 hours)**

Ligand-Based Virtual Screening: Target identification and database construction, Methods for virtual screening (docking, pharmacophore modelling), Scoring functions in ligand-based design; **Pharmacophore Modelling:** Concepts of pharmacophores (features required for biological activity), Tools for pharmacophore design (e.g., PHASE, LigandScout); **Quantitative Structure-Activity Relationship (QSAR):** QSAR theory and methodologies, Descriptors and statistical models (e.g., linear regression, machine learning), Validation of QSAR models (cross-validation, external validation).

Unit V **(8 hours)**

Molecular Docking: Basics of molecular docking (rigid docking vs. flexible docking), Docking algorithms (e.g., AutoDock, Glide, GOLD), Evaluation of docking results (docking scores, RMSD, visualization); **Protein-Ligand Interaction Analysis:** Interpretation of binding modes, Hotspot analysis and key interactions, Structure-activity relationship based on docking results; **Induced Fit Docking:** Concept of induced fit and its role in drug binding, Algorithms for induced fit (e.g., FlexX, Glide); **Docking in Drug Repurposing:** How docking is used to identify novel uses for existing drugs, Case studies of successful drug repurposing.

Unit VI **(10 hours)**

Introduction to MD Simulations: Basics of molecular dynamics and force fields, Role of MD in studying protein-ligand interactions, Time scales and limitations of MD simulations; **Applications of MD Simulations in Drug Design:** Protein-ligand binding affinity prediction, Solvent effects and conformational changes, Free energy calculations; **Softwares for MD Simulations:** Common MD simulation tools (e.g., GROMACS, AMBER, CHARMM), Setting up, running, and analyzing MD simulation trajectory.

Unit VII **(5 hours)**

ADMET (Absorption, Distribution, Metabolism, Excretion, and Toxicity): Importance of ADMET properties in drug design, Prediction tools for ADMET (e.g., ADMETlab, SwissADME), Relationship between molecular structure and ADMET properties; **Toxicity Prediction:** Mechanisms of drug toxicity, In-silico toxicity prediction models, Tools for predicting cytotoxicity, mutagenicity, and carcinogenicity.

Unit VIII **(2 hours)**

Case Studies in Drug Design: Successful applications of CADD in drug discovery, Examples of drugs designed using computational approaches (e.g., HIV protease inhibitors, kinase inhibitors); **Application of CADD in Different Therapeutic Areas:** Cancer, infectious diseases, CNS disorders, cardiovascular diseases, Design of biologics (antibodies, peptides) using CADD; **Future Trends in CADD:** Integration of artificial intelligence and deep learning, Precision medicine and personalized drug design, In silico clinical trials and regulatory considerations.

Tutorial component **(15 hours)**

Software Tools for Molecular Modeling: Introduction to popular CADD software tools (e.g., AutoDock, MOE, Chimera, PyMOL, Gaussian).

Essential/recommended readings

Theory:

1. Structural Bioinformatics. Methods in Molecular Biology Vol. 2112 (first edition). Zoltán Gáspári. ISBN: 978-1071602690
2. Computational Structural Biology: Methods And Applications (first edition). Torsten Schwede and Manuel C. Peitsch (Editors). ISBN: 9789812778772
3. Structural Bioinformatics (second Edition). Jenny Gu and Philip E. Bourne (Editor) ISBN: 978-0-470-18105-8
4. Computational and Structural Approaches to Drug Discovery: Ligand-Protein Interactions (first edition). Robert Stroud and Janet Finer-Moore (Editors). ISBN: 978-0854043651

Practical:

1. Structural bioinformatics tools for drug design extraction of biologically relevant information from structural databases. Jaroslav Koča, Radka Svobodová Vařeková, Lukáš Pravda, Karel Berka, Stanislav Geidl, David Sehnal and Michal Otyepka (authors). ISBN: 978-3-319-47387-1

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE12: COMBATING RARE DISEASES: LEVERAGING IN-SILICO APPROACHES

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		
BP-DSE12: COMBATING RARE DISEASES: LEVERGAING IN-SILICO APPROACHES	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to introduces students to rare diseases and their molecular basis, with a focus on the use of in-silico methods to study these diseases.
- Students will learn to use computational tools that can be applied to uncover the genetic causes of rare diseases, identify potential biomarkers, and develop therapeutic strategies.
- The students will gain hands-on experience with publicly available data, and apply in-silico methods to real-world rare disease data.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to understand the molecular and genetic basis of rare diseases.
- The student will be able to apply in-silico methods, bioinformatics and computational biology approaches to study rare diseases.
- The students will be able to analyze and interpret data from biological databases related to rare diseases.
- The students will be motivated to critically assess scientific literature on in-silico methods in rare disease research.

SYLLABUS OF BP-DSE12

Theory component (45 hours)

UNIT – I Introduction to Rare Diseases (8 hours)

- Definition, prevalence, classification types, and importance in biomedical research.
- Genetic vs. environmental causes of rare diseases.
- Overview of orphan diseases
- Current challenges in diagnosing and treating rare diseases.
- National Policy for rare diseases in India
- Rare diseases prevalent and recognized in India

UNIT – II Genetic Basis of Rare Diseases (8 hours)

- Types of mutations involved, Genetic variants and their identification.
- Techniques for rare disease gene discovery: exome sequencing, genome sequencing, and linkage analysis.

UNIT – III Data sources and databases for Rare Diseases (8 hours)

- Overview of Overview of public databases for rare diseases: OMIM, Orphanet, ClinVar, and the Genetic and Rare Diseases Information Center (GARD).
- The role of patient registries in rare disease research and data collection.

UNIT – IV In-silico tools useful for studying Rare Diseases (8 hours)

- Principles of GWAS, application in identifying genetic variants associated with rare diseases, Interpretation of GWAS data and visualization techniques, Introduction to tools like PLINK, SNPedia, and HapMap for rare disease GWAS analysis.
- Identifying rare disease-causing mutations using tools like SIFT, PolyPhen, CADD.

UNIT – V Identifying Therapeutic targets in Rare Diseases (8 hours)

- Network analysis of pathways: Understanding biological networks and pathways through KEGG, Reactome, and BioGRID
- Understanding protein-protein interactions (PPIs) in the context of rare diseases, using databases like STRING, BioGRID, and Reactome to explore PPI networks, Identifying key regulatory nodes through network visualization.
- Drug repurposing through pathway analysis in rare disease studies.

UNIT – VI Frontiers in Rare Diseases research (5 hours)

- The role of big data in understanding rare diseases, Introduction to AI/ML techniques in rare disease research: clustering, classification, and prediction.
- The future of in-silico drug discovery for rare diseases and personalized medicine.
- Ongoing research and clinical trials for rare disease treatments

Practical component (30 hours)

UNIT I: Databases/Webservers for analysing the following:

1) Analyzing examples of rare disease mutations at the molecular level (e.g., Cystic fibrosis, Duchenne muscular dystrophy).
2) Accessing and analysing data present in OMIM
3) Accessing and analysing data present in Orphanet
4) Accessing and analysing data present in ClinVar
5) Accessing and analysing data present in Genetic and Rare Diseases Information Center (GARD).
6) Learning to mine and use data related to rare diseases in PLINK
7) Learning to mine and use data related to rare diseases in HapMap
8) Learning to mine and use data related to rare diseases in SIFT
9) Learning to mine and use data related to rare diseases in CADD
10) Understanding and extracting information from databases like KEGG
11) Understanding and extracting information from databases like Reactome
12) Understanding and extracting information from databases like BioGRID
13) Case study: Structural analysis of a protein linked to a rare disease.
14) Case study: Pathway analysis through PPI networks of a rare metabolic disorder.
15) Case study: Drug repurposing for rare disease

Essential/Recommended readings

Theory:

- **Books:**

1) *Jules J. Berman (2014). Rare Diseases and Orphan Drugs: Keys to Understanding and Treating the Common Diseases, Academic Press.*

- **Online Resources**:

1) Databases as discussed in practical component
2) https://ojrd.biomedcentral.com/articles/10.1186/s13023-024-03286-8

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE13: PROTEIN ENGINEERING AND 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		
BP-DSE13: **PROTEIN ENGINEERING AND APPLICATIONS**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of the course is to give the students the in-depth understanding and skills necessary for independent target selection and protein engineering to develop novel products for society with problem-solving.
- Another objective is to show the steps necessary for performing such protein engineering for a biotechnology invention.

Learning Outcomes

The Learning Outcomes of this course are as follows:

- The student will be able to analyze the structure of proteins with databases.
- They will be able to analyze and compare the amino acid sequences and structures of proteins and relate this information to function.
- Students will learn the function of individual amino acids and their influence on the solubility, structure, and function of proteins and understand the major factors for protein folding.
- Students will be able to construct bacterial expression plasmids for natural and modified genes and analyze the DNA sequence of proteins for factors that can affect the expression and properties of the protein.
- Based on the above analysis, be able to construct modifications to change the protein's properties.

SYLLABUS OF BP-DSE13

Theory Component (45 hours)

UNIT I **(8 hours)**

Concepts of protein structure and stability: Introduction to protein engineering; Protein structure and function; Protein folding and misfolding; Protein activity-stability-flexibility relationships (enzymatic, thermodynamic and kinetic); Forces stabilizing proteins – van der Waals, electrostatic, hydrogen bonding, covalent and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Correlation between structural features governing protein specificity-and-affinity and biophysical parameters like – pH, temperature, ionic strength, amino acid sequence.

UNIT II **(8 hours)**

Protein engineering concepts, approaches, and applications: Structural features of thermostable, cryostable, and halotolerant proteins. Creation of novel or altered structural proteins, enzymes, antibodies, antigens, transporters, receptors, and transcription factors; Redesign of structure, function, stability, and aggregation; Creation of designer and chimeric/fusion proteins; Combinatorial approaches to protein engineering; Rational approaches to protein engineering; Applications: enzyme engineering, protein allostery, biocatalysis, enzyme immobilization, protein production, antibody therapeutics, natural product biosynthesis.

UNIT III **(10 hours)**

Tools and methods: Molecular visualization (PyMOL, UCSF Chimera,) Molecular modelling (itasser, Alphafold); Recombinant DNA technology-based strategies; Constructs, vectors, strains, affinity fusion tags; Chemical modification strategies; Site-directed mutagenesis – PCR-based and primer extension methods, Use of labels; Heterologous protein expression; Protein purification approaches; Protein handling; Protein biochemical and physico-chemical characterization using - ELISA, BLI, far-UV and near-UV CD, Fluorescence spectroscopy, UV absorbance, ORD, FTIR.

UNIT IV **(9 hours)**

Combinatorial Protein Engineering: Chemical mutagenesis; Error-prone PCR; Synthetic peptide combinatorial libraries; V_H-V_L combinatorial scFv libraries, Principles and applications of phage, ribosome, yeast and bacterial display; Module shuffling; Gene site saturation mutagenesis; Selection and screening approaches for folding and function - high throughput screening methodologies like GigaMetrix, High throughput microplate screens; Applications.

UNIT V **(10 hours)**

Rational Protein Engineering: Guided protein recombination; Domain or sub-structure fusion; Backbone Reversal; Global conservative mutagenesis; Excision of super-secondary structures; Substructure shuffling with symmetric structures; Surface reengineering to obviate aggregation; Disulphide bond introduction to prevent domain dissociation; Topology scrambling through loop redesign; Active surface transplants between homologous beta-sheet proteins; Whole surface transplants; Enzyme active site transplants; Loop transplants on beta/alpha barrels; Site-directed mutagenesis to alter protein kinetic stability or thermodynamic stability; Protein hydrophobic core reengineering; Reengineering of protein surface electrostatics; Thermostability and cryostability engineering; Applications.

Practical component (30 hours)

1. Selection of target proteins for engineering using various data bases.
2. Identification of possible sites for mutagenesis combining the literature information and molecular visualization of the structure of the target protein.
3. Generation of mutant sequences and model generation.
4. Validation of the models using Ramachandran plot, using online software.
5. Structural comparison of the mutant protein models with wild-type protein for selection of the stable mutant.
6. Molecular dynamic simulation studies with the mutant and wild-type proteins.
7. Molecular docking studies with the selected mutant(s) and the ligand for prediction of the functional characteristics of the mutants.

Essential/recommended readings

1. Introduction to Proteins: Structure, Function, and Motion, Second Edition By Amit Kessel, Nir Ben-Tal, Chapman and Hall/CRC, 2018
2. Edited by T E Creighton, (1997), *Protein Structure: a Practical Approach*, 2nd Edition, Oxford University Press.
3. Cleland and Craik, (2006), *Protein Engineering, Principles and Practice*, Vol 7, Springer Netherlands.
4. Mueller and Arndt, *Protein Engineering Protocols*, 1st Edition, Humana Press.
5. Ed. Robertson DE, Noel JP, (2004), *Protein Engineering Methods in Enzymology*, 388, Elsevier Academic Press.
6. J Kyte; (2006), *Structure in Protein Chemistry*, 2nd Edition, Garland publishers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

DISCIPLINE SPECIFIC ELECTIVE COURSE – BP-DSE14: ARTIFICIAL INTELLIGENCE, MACHINE LEARNING AND DEEP LEARNING IN BIOMEDICAL SCIENCES

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		
BP-DSE14: **ARTIFICIAL INTELLIGENCE, MACHINE LEARNING AND DEEP LEARNING IN BIOMEDICAL SCIENCES**	**4**	**3**	**0**	**1**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- Communicate machine learning concepts and results effectively to both technical and non-technical audiences, using appropriate visualizations and language.
- Explain the concepts of artificial intelligence/machine learning, including supervised and unsupervised learning, deep neural networks, and optimization.
- Explain how machine learning could begin to be integrated into their own research.
- Identify applications AI/ML models Biomedical applications.

Learning Outcomes

By the end of the course, students will be able to:

- Understand and apply basic AI/ML and Deep Learning algorithms for classification, regression, and clustering.
- Preprocess and clean datasets, as well as engineer features for ML and Deep Learning models.
- Implement and evaluate AI/ML and Deep Learning models using popular libraries like scikit-learn, TensorFlow, or PyTorch.
- Apply deep learning techniques to more complex problems.

SYLLABUS OF BP-DSE14

Theory component (45 hours)

Unit I (2 hours)

Introduction to AI and ML: Introduction and subfields of Artificial Intelligence; **Overview and Types of Machine Learning**: Types (Supervised, Unsupervised, Reinforcement Learning, Large Language Models), AI vs. ML vs. Deep Learning

Unit II (2 hours)

Data Cleaning: Handling missing data, outliers, and noise, Normalization, standardization, and scaling; **Feature Engineering:** Feature selection vs. feature extraction, Encoding categorical variables; **Data Splitting:** Train-test split, validation sets, cross-validation techniques

Unit III (5 hours)

Regression Algorithms: Linear Regression: Assumptions, cost function, and gradient descent, Regularized Regression: Lasso and Ridge Regression, Polynomial Regression; **Classification Algorithms:** Logistic Regression and its application, k-Nearest Neighbors (k-NN), Support Vector Machines (SVM), Decision Trees and Random Forests, Naive Bayes classifier; **Evaluation Metrics:** Accuracy, precision, recall, F1-score, Confusion matrix, ROC curves, AUC

Unit IV (5 hours)

Clustering Algorithms: K-Means Clustering, Hierarchical Clustering, DBSCAN (Density-Based Spatial Clustering); **Dimensionality Reduction:** Principal Component Analysis (PCA), t-SNE (t-distributed Stochastic Neighbor Embedding); Autoencoders.

Unit V (5 hours)

Overfitting and Underfitting: Bias-variance tradeoff, Cross-validation techniques; **Hyperparameter Tuning:** Grid Search and Random Search for hyperparameter optimization, Bayesian Optimization (Introduction); **Ensemble Methods:** Bagging and Boosting: Random Forest, AdaBoost, Gradient Boosting, XGBoost, LightGBM, and CatBoost

Unit VI (8 hours)

Introduction to Neural Networks: Artificial Neurons and Activation Functions (Sigmoid, ReLU, Tanh), Feedforward Neural Networks and Backpropagation, Loss functions (Mean Squared Error, Cross-Entropy); **Deep Learning Concepts:** Introduction to Convolutional Neural Networks (CNNs) for image processing, Introduction to Recurrent Neural Networks (RNNs) for sequential data, Transfer Learning and Fine-Tuning;

Unit VII (5 hours)

Introduction to Reinforcement Learning (RL): Key concepts: Agents, Environment, Rewards, Actions, Markov Decision Processes (MDP); **Basic RL Algorithms:** Q-Learning, Policy Gradient Methods; **Deep Reinforcement Learning:** Deep Q-Networks (DQN), Introduction to AlphaGo and other advanced RL techniques,

Unit VIII **(5 hours)**

Bias and Fairness in AI: Identifying and mitigating bias in data and models, Fairness in machine learning algorithms; **Explainability and Interpretability:** Why and how to explain AI decisions (LIME, SHAP),

Unit IX **(4 hours)**

Use of AI/ML in Healthcare: Applications of AI and ML in medical image analysis, medical image segmentation, detecting cancers in radiology images, classifying retinal images for diabetic retinopathy, The impact of AI/ML in diagnostics, personalized medicine, drug discovery, genomics and electronic health records (EHRs).

Unit X **(4 hours)**

Application and Use of AI in Augmented & Virtual Reality: Introduction to Augmented Reality Virtual Reality and Virtual Environment, Usage of Augmented & Virtual Reality in biomedical research.

Practical component (30 hours)

- Implementing machine learning models on real datasets, Classification problems, regression problems, and clustering tasks, Building a simple recommendation system
- Introduction to TensorFlow and PyTorch

Essential/recommended readings

Theory:

1. Machine Learning For Absolute Beginners: A Plain English Introduction (Second Edition). ISBN: 979-8558098426
2. Python Data Science Handbook. Jake VanderPlas. ISBN: 9781491912058
3. Deep Learning for the Life Sciences: Applying Deep Learning to Genomics, Microscopy, Drug Discovery, and More. Bharath Ramsundar, Peter Eastman, Patrick Walters, Vijay Pande (authors). ISBN: 978-9352138333
4. Pattern Recognition and Machine Learning (third edition). Christopher M. Bishop (Author). ISBN: 978-1119741749
5. Becoming a Data Head: How to Think, Speak, and Understand Data Science, Statistics, and Machine Learning. Alex J. Gutman, Jordan Goldmeier (authors). ISBN: 978-1119741749
6. scikit-learn Cookbook (second edition). Julian Avila, Trent Hauck (authors). ISBN: 978-1-78728-638-2

Practical:

1. Machine Learning: Hands-On for Developers and Technical Professionals (first edition). Jason Bell (Author). ISBN: 978-1118889060
2. Hands-On Machine Learning with Scikit-Learn and TensorFlow (third edition). Aurélien Géron. ISBN: 978-9355421982

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

M.Sc. Biophysics and Bioinformatics

SKILL BASED COURSE – BP-SB04: SPECIALISED LABORATORY – IV: Advanced Analytical Methods

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		
BP-SB04: SPECIALISED LABORATORY-IV: Advanced Analytical Methods	**2**	**0**	**0**	**2**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this skill enhancement laboratory course is to provide analytical skills of advanced protein related experiments.
- Student will be taught various types of chromatography for protein purification
- To expose students to the software related to analysis of analytical ultra-centrifugation

Learning Outcomes

The Learning Outcomes of this course are as follows:

- To students will be able to execute the affinity chromatography experiment.
- Students will be able to perform experiment of size exclusion chromatography.
- Students will be able to perform analysis by using software related to analytical ultra-centrifugation.

SYLLABUS OF BP-SB04

Practical component (60 hours)

Unit I

1. Affinity purification of proteins (HIS-Tag).
2. Demonstration of Gel filtration.
3. Crystallization setup of proteins
4. Data analysis of Analytical Ultracentrifuge: SEDFIT software
5. Data analysis of Analytical Ultracentrifuge: SEDPHAT software
6. Data analysis of Analytical Ultracentrifuge: GUSSI software
7. Case study/Group Discussion of data analysis and results.

Essential/recommended readings

1. Schuck, P., Zhao, H., Brautigam, A. C., Ghirlando, R., BASIC PRINCIPLES OF ANALYTICAL ULTRACENTRIFUGATION. CRC Press.
2. Schuck, P., Zhao, H., SEDIMENTATION VELOCITY ANALYTICAL ULTRACENTRIFUGATION: Interacting Systems. CRC Press. Arnolds.
3. Freifelder, David Michael; PHYSICAL BIOCHEMISTRY : APPLICATIONS TO BIOCHEMISTRY AND MOLECULAR BIOLOGY; W.H. Freeman and Company.

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M.Sc. Biophysics and Bioinformatics

Research Track – BP-RT03: TECHNIQUES OF RESEARCH WRITING

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		
BP-RT03: **TECHNIQUES OF RESEARCH WRITING**	**2**	**2**	**0**	**0**	**NIL**	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- To provide students with knowledge of structure of scientific communications.
- To provide students with and understanding of publishing process
- To help students master data presentation and visualization

Learning Outcomes

The Learning Outcomes of this course are as follows:

- To students will be able to Write well-structured scientific papers, reports, and proposals
- Students will develop the ability to communicate their research findings effectively through presentations and poster.
- Students would be capable of navigate the peer-review and publication process

SYLLABUS OF BP-RT03

Theory component (30 hours)

Unit I: Research Writing (8 hours)

- Types of Research writing: Research paper writing: Preparation of Manuscripts;, book reviews; Difference between literature review for thesis and review articles,
- Prewriting considerations: identify the audience and purpose
- Manuscript preparation: Structure, language and style, Difference between summary and abstracts; referencing and citation methods/styles; Foot–notes, diagrams, bibliographies, index, quotation and translation;
- Presenting at Conferences and Meetings: Making posters, Delivering oral presentation; Conference presentations *vs* dissertation presentations.
- Writing research grant proposals: preliminary data

Unit II: Publishing Research (8 hours)

- Selection of journals: How to identify suitable journals, Understanding journal ranking systems (Scopus, Web of Science), Predatory journals and how to avoid them
- Models of publishing: Open source *vs* traditional journal publishing
- The Peer-Review Process: Authorship criteria and disputes (first author, corresponding author, acknowledgments), Conflicts of interest and disclosure policies, Retractions and corrections in scientific publishing, Duplicate submission and self-plagiarism
- Publication acceptance and post-publication: Manuscript acceptance and proof correction, Copyright and licensing (Creative Commons, publisher agreements)
- Alternative Research Dissemination options: reprint servers (arXiv, bioRxiv, SSRN)

Unit III: Journal and Paper Indices (8 hours)

- Understanding publication Metrices: impact factors, h-index, citation metrics
- Reference management software.

Unit IV: Case Study (6 hours)

- Drafting a research proposal/grant proposal

Essential/recommended readings

Online Resources as discussed in class

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