UNIVERSITY OF DELHI

MASTER OF SCIENCE (BIOCHEMISTRY)
(PGCF NEP-2020)

Syllabus approved by Committee of Courses on 18th February 2026 and FIAS on 23 February 2026

SEMESTER-WISE PROGRAM STRUCTURE OF M.Sc. BIOCHEMISTRY COURSE

(PGCF NEP-2020)

PG Curricular structure with only course work – 1st year / 2nd year

Semester-3

	Credits in each course			
	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
DSC-07: Experimental Methods in Biochemistry	3	0	1	4
DSC-08: Gene Expression and Gene Regulation	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-05: Advanced Immunology	3	1	0	4
DSE-06: Biosafety, Bioethics and Biosecurity	3	1	0	4
DSE-07: Principles in Genetics	3	0	1	4
Skill enhancement course (SEC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SBC-03: Tools for Biostatistics and Data Visualization	0	0	2	2
Total credits				22
Generic Elective (GE) courses*				
GE-3: Biochemistry of Human Diseases	3	1	0	4

Semester-4

	Credits in each course			
	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
DSC-09: Recombinant DNA Technology and Functional Genomics	3	1	0	4
DSC-10: Biotechnology for Human Health	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-08: Advanced Proteomics and Metabolomics	3	0	1	4
DSE-09: Disease Models and Clinical Research	3	1	0	4
DSE-10: AI and its applications in Biomedicine and Biotechnology	3	0	1	4
Skill enhancement course (SEC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SBC-04: Scientific Research writing	0	0	2	2
Total credits				22
Generic Elective (GE) courses*				
GE-4: Biochemical Techniques and Applications	3	1	0	4

SEMESTER-WISE PROGRAM STRUCTURE OF M.Sc. BIOCHEMISTRY COURSE

(PGCF NEP-2020)

PG Curricular structure with course work + Research – 1st year / 2nd year

Semester-3

	Credits in each course			
	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
DSC-07: Experimental Methods in Biochemistry	3	0	1	4
DSC-08: Gene Expression and Gene Regulation	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-05: Advanced Immunology	3	1	0	4
DSE-06: Biosafety, Bioethics and Biosecurity	3	1	0	4
Dissertation/ Academic Project/ Entrepreneurship	0	0	6	6
Total credits				22
Generic Elective (GE) courses*				
GE-3: Biochemistry of Human Diseases	3	1	0	4

Semester-4

	Credits in each course			
	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
DSC-09: Recombinant DNA Technology and Functional Genomics	3	1	0	4
DSC-10: Biotechnology for Human Health	3	1	0	4
Discipline Specific Elective (DSE) courses*				
DSE-08: Advanced Proteomics and Metabolomics	3	0	1	4
DSE-09: Disease Models and Clinical Research	3	1	0	4
Dissertation/ Academic Project/ Entrepreneurship	0	0	6	6
Total credits				22
Generic Elective (GE) courses*				
GE-4: Biochemical Techniques and Applications	3	1	0	4

SEMESTER-WISE PROGRAM STRUCTURE OF M.Sc. BIOCHEMISTRY COURSE

(PGCF NEP-2020)

PG Curricular structure with Research only – 1st year / 2nd year (Only for B.Sc. (H) Biochemistry

Semester-3

	Credits in each course			
	Theory	Tutorial	Practical	Credits
Discipline Specific Core (DSC) courses				
DSC-11: Advanced Techniques in Biochemistry	3	0	1	4
Discipline Specific Elective (DSE) courses*				
DSE-05: Advanced Immunology	3	1	0	4
Skill enhancement course (SEC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SEC-RM: Advanced Research Methodology	1	0	1	2
SBC-03: Tools for Biostatistics and Data Visualization	1	0	1	2
Dissertation/ Academic Project/ Entrepreneurship	0	0	10	10
Total credits				22

Semester-4

	Credits in each course			
	Theory	Tutorial	Practical	Credits
Discipline Specific Elective (DSE) courses*				
DSE-08: Advanced Proteomics and Metabolomics	3	0	1	4
Skill enhancement course (SEC)/ workshop/ Specialized laboratory/ Hands-on Learning				
SBC-04: Scientific Research writing	0	0	2	2
Dissertation/ Academic Project/ Entrepreneurship	0	0	16	16
Total credits				22

DISCIPLINE SPECIFIC CORE COURSE – DSC-07: EXPERIMENTAL METHODS IN BIOCHEMISTRY

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		
DSC-07: Experimental Methods in Biochemistry	**04**	**03**	**0**	**01**	**B.Sc. Biochemistry and Allied Subjects**	**-**

Number of hours: 45 (T) + 30 (P)

Course Objectives:

This course is intended to provide a comprehensive understanding of modern laboratory methods widely used in biochemical and molecular research. It covers experimental approaches for cell-based studies, nucleic acid and protein analysis, regulation of gene expression, amplification and sequencing methods, and their use in research and biotechnology. The paper also familiarizes students with experimental design, data interpretation, and laboratory safety associated with contemporary biological techniques.

Learning Outcomes

Upon successful completion of the course, students will be able to:

1. Carry out and interpret cell-based experimental approaches used for studying growth, survival, proliferation, and gene manipulation;
2. Apply laboratory methods for isolation, detection, and analysis of DNA, RNA, and proteins;
3. Examine gene regulation and nucleic acid–protein interactions using molecular assays;
4. Perform and interpret amplification-based and sequencing-based approaches for analysis of genes and transcripts;
5. Analyze experimental results and relate suitable techniques to specific biological questions in research and biotechnology.

Course Contents

Unit I Cell Culture methods **11 Hours**

Introduction to mammalian cell culture and its role in biomedical research. Basic principles of maintaining and handling cultured cells. Overview of gene manipulation in cells and generation of lines. Basic concepts of the cell cycle and methods used to study cell cycle progression, various cell-based assays to evaluate cell viability, cytotoxicity, proliferation, and apoptosis.

Essential Readings:

1. Sambrook, J. & Russell, D. W. *Molecular Cloning: A Laboratory Manual*, Vol. I, 4th Edition, Cold Spring Harbor Laboratory Press. Chapters 16, 17, 18.
2. Wilson, K. and Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*, 7th Edition, Cambridge University Press. Chapters 2, 6, 7.
3. Alberts, B. et al. (2022). *Molecular Biology of the Cell*, 7th Edition, W. W. Norton & Company. Chapters 6, 7, 8, 9, 12, 17.
4. Ramkumar, K. M., Senthilkumar, R., & Hoque, Md Enamul (Eds.). (2023). *Advanced Mammalian Cell Culture Techniques: Principles and Practices*. CRC Press. Chapters 7, 13, 14, 15, 21, 23, 25.

Unit II: Techniques for Studying Gene Expression and Regulation 12 Hours

Introduction to the basic concepts of nucleic acid isolation, and quality assessment of plasmid DNA, genomic DNA, and RNA, and their importance in biological research. Principles of gel electrophoresis for the separation and analysis of nucleic acids. Overview of classical blotting techniques including Southern, Northern, and Western blotting and their applications in detecting DNA, RNA, and proteins. Basic concepts of *in vitro* transcription and translation systems used to examine gene expression and protein synthesis. Overview of RNase protection assay for analyzing transcript expression. Principles of chromatin immunoprecipitation (ChIP) and reporter gene assays for investigating transcriptional regulation.

Essential Readings:

1. Wilson, K. and Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*, 7th Edition, Cambridge University Press. Chapters 5, 6, 9.
2. Alberts, B. et al. (2022). *Molecular Biology of the Cell*, 7th Edition, W. W. Norton & Company. Chapters 6,7, 9.
3. Ramkumar, K. M., Senthilkumar, R., & Hoque, Md Enamul (Eds.). (2023). *Advanced Mammalian Cell Culture Techniques: Principles and Practices*. CRC Press. Relevant chapters.
4. Sambrook, J. & Russell, D. W. *Molecular Cloning: A Laboratory Manual*, Vol. I, 4th Edition, Cold Spring Harbor Laboratory Press. Chapters 6-9,11,12,15.

Unit III: Techniques for Studying Proteins and their Interactions 11 Hours

Experimental approaches to study proteins- Mass Spectrometry, CD and NMR. Techniques for protein-protein and DNA-protein interaction studies, including Immunoaffinity methods, Electrophoretic Mobility Shift Assay (EMSA), DNA footprinting, Two-hybrid System,

Essential Readings:

1. Wilson, K. and Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*, 7th Edition, Cambridge University Press. Chapters 7, 9 and 11.
2. Srivastava, S. (2023) From Proteins to Proteomics. Basic concepts, techniques and Applications. Sanjeeva Srivastava, 2023, CRC Press, Taylor & Francis Ltd. Chapter 1, 2.
3. Gross, Juergen H; Roepstorff, Peter (2011, 2nd edition). Mass Spectrometry: A Textbook, Springer. Chapter 4, 5.

Unit IV: Amplification, gene modification, and sequencing methods **11 Hours**

Principles of nucleic acid amplification and parameters influencing reaction performance. Primer planning, reaction assembly, and optimization steps. Different PCR formats, including conventional PCR, nested PCR, multiplex PCR, reverse transcription PCR, and quantitative real-time PCR. Introduction to site-directed mutagenesis and its use in sequence alteration studies. Fundamentals of DNA and RNA sequencing, including Sanger chain-termination sequencing, chromatogram reading, and interpretation. Overview of next-generation sequencing workflow and its applications in biological research.

Essential Readings:

1. Sambrook, J. & Russell, D. W. *Molecular Cloning: A Laboratory Manual*, 4th Edition, Cold Spring Harbor Laboratory Press. Chapters 7–10.
2. Krebs, Jocelyn E., Goldstein, Stephen B., & Kilpatrick, Elliott W. *Lewin's GENES XII*, 12th Edition, Jones & Bartlett Learning. Chapter 3.

Practical **30 Hours**

1. Maintenance and subculturing of mammalian cells; cell counting, viability testing.
2. Isolation of plasmid DNA and RNA; agarose gel analysis; restriction digestion; preparation and analysis of amplification reactions including PCR and RT-PCR/qRT-PCR data interpretation.
3. Demonstration-based exposure to immunoprecipitation and mass spectrometry.
4. Analysis of sequencing chromatograms, primer design exercises, amplification planning, and guided interpretation of representative datasets related to gene expression and sequencing-based experiments.

Essential Readings:

1. Sambrook, J. & Russell, D. W. Molecular Cloning: A Laboratory Manual Vol I (4th Edition, Cold Spring Harbor Laboratory Press). Chapters- 16, 18, 17
2. K. Wilson and J. Walker. (2010) Principles and Techniques of Biochemistry and Molecular Biology (7th Edition), Cambridge University Press: Chapters: 2, 7 and 6
3. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell* (7th ed.). W. W. Norton & Company. Chapters 6,7,8, 9,12 and 17.
4. Ramkumar, K. M., Senthilkumar, R., & Hoque, Md Enamul (Eds.). (2023). *Advanced Mammalian Cell Culture Techniques: Principles and Practices*. CRC Press. Chapters 7,13, 14,15,21,23 and 25.

Suggested Readings:

1. G.M. Cooper. 2000. The Cell: Molecular Approach, ASM Press, Washington, D.C. USA.
2. J.R. Harris, J. M. Graham, D. Rickwood. (2006) Cell Biology Protocols. J Wiley and Sons Inc.
3. D. Sheehan. 2009. Physical Biochemistry: Principles and Applications (2nd Ed.), John Wiley and Sons Ltd, Chichester, England. ISBN: 978-0-470-85603-1.

4. J. Cavanagh, W.J. Fairbrother, A.G. Palmer III, M. Rance, N. J. Skelton. 2007. Protein NMR Spectroscopy: Principles and Practice, Academic Press, San Diego, USA. ISBN: 978-0-12-164491-8.
5. Advanced Biophysical Techniques in Biosciences. Editors: Nirmal Mazumder, Rajib Biswas, Guan-Yu Zhuo. Springer
6. Biophysical Techniques in Biochemistry and Molecular Biology – Van Holde & Johnson, Prentice Hall
7. Molecular Biophysics – Michel Daune, Oxford Univ. Press

DISCIPLINE SPECIFIC CORE COURSE – DSC-08: GENE EXPRESSION AND GENE REGULATION

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		
DSC-08: Gene Expression and Gene Regulation	04	03	01	0	-	-

Number of hours: 45 (T) + 15 (T)

Learning Objectives:

The objective is to offer detailed knowledge about the concept of genome, mechanisms of DNA replication, gene expression and translation in prokaryotes and eukaryotes so that students can apply this knowledge in enhancing their analytical and research problem solving skills.

Learning Outcomes:

- Students will acquire basic concepts of genome, its organization and maintenance in various life forms.
- Students will learn how DNA is replicated and repaired and hence the consequences of improper processes.
- Students will gain knowledge about the mechanisms of transcription, post- transcriptional processes and regulatory mechanisms governing over-expression and under-expression of genes. The knowledge gained will be utilized to design experiments.
- Students will understand the concept of Open Reading Frame and will be able to apply it in design of primers for gene amplification and cloning for heterologous expression.

Course Contents

Unit I: The structure of DNA and RNA; Organization of Microbial Genomes, Biosynthesis of RNA (Transcription) in prokaryotes: General features of transcription, Discovery of RNA polymerase, Bacterial RNA polymerase, Identification and characterization of promoters, consensus sequences, up and down mutations in promoters. Conserved regions of sigma factors and their role in DNA binding. Elongation, Termination, intrinsic and rho dependent termination, mechanism of action of rho. Anti-termination and gene regulation, Inhibitors of transcription and applications as anti-microbial drugs.

11 hours

Essential Readings:

1. B. Lewin, J. Krebs, S.T. Kilpatrick, E.S. Goldstein (2018). Genes XII, Jones and Bartlett Publishers, Sudbury, Massachusetts, USA. Chapters: 1, 4, 7, 8, 17, 19.
2. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. (2013). Molecular Biology of the Gene (7^{th} ed). Benjamin Cummings, San Francisco, USA. Chapters: 4,5, 6, 8, 13, 14, 18, 19,20

Unit II: Organization of Eukaryotic Genomes. DNA Replication: isolation and mapping of replication origins. Discovery and properties of DNA polymerases. Mode of action of inhibitors and their therapeutic applications. Regulation of replication initiation, role of replication enzymes and modes of replication. Discovery and mechanism of action of Reverse transcriptase and Telomerase and their significance. DNA Repair: Types of DNA damages, DNA repair systems including photoreactivation, excision repair, base flipping, mismatch repair, recombination repair, transcription coupled repair and SOS repair. Diseases associated with DNA replication and repair problems.

11 hours

Essential Readings:

1. B. Lewin, J. Krebs, S.T. Kilpatrick, E.S. Goldstein (2018). Genes XII, Jones and Bartlett Publishers, Sudbury, Massachusetts, USA. Chapters: 7, 8, 9, 10, 11, 12, 13, 14, 15, 20, 11
2. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. (2013). Molecular Biology of the Gene (7^{th} ed). Benjamin Cummings, San Francisco, USA. Chapters: 8, 9, 10, 11, 12

Unit III: Eukaryotic Transcription: Characteristics of promoter and enhancer elements. Activators and repressors of transcription, different DNA binding domains. Discovery, properties and functions of three eukaryotic RNA polymerases, their mode of action and specific inhibitors. Composition and function of basal transcription apparatus, including general transcription factors involved in initiation, elongation, and termination. as well as maturation pathways for rRNA and tRNA. Introduction to ribozymes and catalytic RNA mechanisms, and RNA editing. Regulation of gene expression at the chromatin level, with emphasis on chromatin remodeling complexes, histone modifications, and epigenetic gene silencing pathways such as DNA methylation and RNA interference.

12 hours

Essential Readings:

1. B. Lewin, J. Krebs, S.T. Kilpatrick, E.S. Goldstein (2018). Genes XII, Jones and Bartlett Publishers, Sudbury, Massachusetts, USA. Chapters: Chapter – 17, 18, 19, 20, 21, 26 27, 28, 30
2. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. (2013). Molecular Biology of the Gene (7th ed). Benjamin Cummings, San Francisco, USA. Chapters: 13, 14, 16, 15, 18, 19,20

Unit IV: Protein synthesis in prokaryotes and eukaryotes: Concept of Genetic code Relationship between genes and proteins, concept of tRNA, triplet nature of genetic code, concept of mRNA, elucidation of genetic code, universality of genetic code, Wobble hypothesis and exceptions, degeneracy of genetic code, general features translation, activation of amino acids. Initiation: initiator tRNAs, RBS, initiation complex, initiation factors.

Elongation: Elongation factors, peptide bond formation, translocation. Termination: release factors, ribosome release factors, polycistronic/ monocistronic synthesis, differences between prokaryotes and eukaryotes, coupling of transcription and translation. Role of antibiotics in understanding protein synthesis, Mode of action of various antibiotics in the inhibition of protein synthesis. Principles of gene regulation, negative and positive regulation, concept of operons, regulatory proteins.

12 hours

Essential Readings:

1. B. Lewin, J. Krebs, S.T. Kilpatrick, E.S. Goldstein (2018). Genes XII, Jones and Bartlett Publishers, Sudbury, Massachusetts, USA. Chapters: 22,23,24, 25, 26
2. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. (2013). Molecular Biology of the Gene (7th ed). Benjamin Cummings, San Francisco, USA. Chapters: 14, 15, 16, 22

Tutorial **15 Hours**

1. Critical analysis of landmark discoveries in DNA replication, transcription, and translation, emphasizing the experimental techniques employed and the significance of their findings.
2. Discussion on the experimental workflow for elucidation of the Genetic Code.
3. Discussion on variations in pathogenic bacteria in Gene expression and its relevance in pathogenesis.
4. Case studies on diseases linked to defects in DNA replication, repair, and transcription, followed by critical discussions on underlying molecular mechanisms and therapeutic implications.

Essential Readings:

1. B. Lewin, J. Krebs, S.T. Kilpatrick, E.S. Goldstein (2018). Genes XII, Jones and Bartlett Publishers, Sudbury, Massachusetts, USA.
2. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. (2013). Molecular Biology of the Gene (7th ed). Benjamin Cummings, San Francisco, USA.

Suggested Readings:

1. D.L. Nelson, M.M. Cox. (2021). Lehninger Principles of Biochemistry (8th Edition), W.H. Freeman and Company, New York, USA.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. (2012) Biochemistry (7th Edition), W.H. Freeman and Company; New York, USA.
3. B. Lewin, J. Krebs, S.T. Kilpatrick, E.S. Goldstein (2018). Genes XII, Jones and Bartlett Publishers, Sudbury, Massachusetts, USA.
4. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. (2013). Molecular Biology of the Gene (7th edition). Benjamin Cummings, San Francisco, USA.
5. R.F. Weaver (2007). Molecular Biology. (4th edition). McGraw Hill. New York. USA.
6. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter (2015). Molecular Biology of the Cell (6th Edition), Garland Science, New York, USA.

7. H. Lodish, B. Harvey, Arnold, S. Zipursky, S. Lawrence, P. Matsudaira, D. Baltimore, J. Darnell, E. James. (2008). Molecular Cell Biology. (6th Edition) W.H. Freeman and Company, New York, USA.
8. G. M. Cooper and R.E. Hausman. (2013). The Cell: A Molecular Approach (6th Edition), Sinauer Associates, Inc. Massachusetts, USA.
9. R.H. Garrett, C.M. Grisham. 2010. Biochemistry, Saunders College Publishers, Texas, USA

DISCIPLINE SPECIFIC CORE COURSE – DSC-09:
RECOMBINANT DNA TECHNOLOGY AND FUNCTIONAL GENOMICS

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		
DSC-09: Recombinant DNA Technology and Functional Genomics	**04**	**03**	**01**	**0**	**B.Sc. Biochemistry and Allied Subjects**	**-**

Number of hours: 45 (T) + 15 (T)

Learning Objectives:

The course aims to provide an in-depth understanding of the molecular principles and experimental strategies underlying recombinant DNA technology and modern genomics. It introduces students to restriction–modification systems, plasmid and phage vector biology, and the design of cloning strategies for gene manipulation. The course further familiarizes students with next-generation sequencing technologies, transcriptomic approaches, and advanced genome-editing tools such as CRISPR–Cas systems. Emphasis is placed on developing conceptual and practical competence in genetic engineering, data interpretation, and the applications of these technologies in biotechnology and biomedical research.

Learning Outcomes

On successful completion of this course, students will be able to:

1. Explain the mechanisms and applications of restriction–modification systems and perform basic molecular techniques such as restriction digestion and electrophoresis.
2. Describe the biology of plasmids and bacteriophages and analyze their use in the design of cloning and expression vectors for gene manipulation.
3. Discuss the principles and workflows of next-generation sequencing (NGS), transcriptomics, and comparative genomics for genome-wide analysis.
4. Apply advanced genetic engineering tools including CRISPR–Cas systems and RNA interference for targeted genome modification and functional studies.
5. Evaluate modern applications of recombinant DNA and genome-editing technologies in biotechnology, functional genomics, and disease research.

Course Contents

Unit I: Restriction and modification systems and their significance in recombinant DNA technology; types and mechanisms of restriction endonucleases and modification enzymes; recognition sequences and cleavage patterns; applications of restriction enzymes in cloning and molecular diagnostics. Basic techniques in RDT: agarose gel electrophoresis for DNA separation and visualization, polyacrylamide gel electrophoresis (PAGE) for nucleic acids and proteins, and pulse-field gel electrophoresis for large DNA fragments.

12 Hours

Essential Readings:

1. Sambrook, J. & Russell, D.W. Molecular Cloning: A Laboratory Manual (4th Edition, Cold Spring Harbor Laboratory Press). Chapters: 5, 6, 8, 9.
2. Brown, T. A. Gene Cloning and DNA Analysis: An Introduction (7th Edition, Wiley-Blackwell). Chapters: 2, 3, 5, 6.
3. Wilson, K. & Walker, J. Principles and Techniques of Biochemistry and Molecular Biology (7th Edition, Cambridge University Press). Chapters: 2, 5, 7.

Unit II: Basic biology of plasmids: replication mechanisms, copy number control, and incompatibility groups. Design and development of plasmid vectors with selectable markers and reporter genes; screening and selection strategies in cloning. Biology of filamentous phages (M13) and development of phage and phagemid vectors for DNA sequencing, mutagenesis, and phage display. Biology of bacteriophage lambda (λ): promoters and control circuits, packaging mechanisms, and use in vector construction. Vectors for cloning large fragments of DNA-cosmids, BACs (bacterial artificial chromosomes), and YACs (yeast artificial chromosomes).

12 Hours

Essential Readings:

1. Brown, T. A. Gene Cloning and DNA Analysis: An Introduction (7th Edition, Wiley-Blackwell). Chapters: 4, 7, 8, 9.
2. Sambrook, J. & Russell, D.W. Molecular Cloning: A Laboratory Manual (4th Edition, Cold Spring Harbor Laboratory Press). Chapters: 1, 3, 7, 17.
3. Primrose, S. B. & Twyman, R. M. Principles of Gene Manipulation and Genomics (7th Edition, Wiley-Blackwell). Chapters: 4, 5, 6, 8.

Unit III: Principles and applications of next-generation sequencing (NGS) technologies: whole-genome sequencing, exome sequencing, RNA sequencing (RNA-seq), and ATAC-seq for chromatin accessibility profiling. Single-cell genomics and spatial transcriptomics for cell- type–specific gene expression profiling. Comparative genomics and evolutionary insights from genome-wide analyses.

11 Hours

Essential Readings:

1. Brown, T. A. Genomes (4th Edition, Garland Science). Chapters: 16, 17, 18, 19.
2. Gibson, G. A Primer of Genome Science (3rd Edition, Sinauer/Oxford). Chapters: 6, 7, 8.
3. Lesk, A. M. Introduction to Genomics (3rd Edition, Oxford University Press). Chapters: 9, 10, 11.

Unit IV: Genome editing tools: CRISPR–Cas systems, base editing, and prime editing technologies; comparison with ZFNs and TALENs. RNA interference (RNAi): mechanism, design of siRNA and shRNA, and applications in gene silencing. Gene knock-out and knock- in models using homologous recombination and CRISPR technologies in various organisms.

10 Hours

Essential Readings:

1. Doudna, J. A. & Sternberg, S. H. A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution (Houghton Mifflin Harcourt). (For concept + ethics overview; instructor-guided.)
2. Glick, B. R., Pasternak, J. J., & Patten, C. L. Molecular Biotechnology (4th Edition, ASM Press). Chapters: (Genome editing, RNAi, gene silencing—relevant sections).
3. Watson, J. D. et al. Recombinant DNA: Genes and Genomes—A Short Course (3rd Edition, W.H. Freeman). Chapters: (Gene targeting, transgenics, genome manipulation— relevant sections).

Tutorial **15 Hours**

1. Demonstration of restriction digestion and agarose gel electrophoresis for visualizing DNA fragments.
2. Interactive exploration of plasmid and phage vector maps using tools like SnapGene or Benchling.
3. Virtual simulation of CRISPR–Cas genome editing and RNA-seq data analysis using web-based platforms.
4. Case study–based discussion on experimental design in recombinant DNA technology, including selection of appropriate vectors (plasmid, phage, BAC/YAC), cloning strategies for large DNA fragments, and interpretation of NGS-based genome editing outcomes.

Essential and Suggested Reading

1. Krebs, Jocelyn E., Goldstein, Stephen B., & Kilpatrick, Elliott W. Lewin's GENES XII (12th Edition), Jones & Bartlett Learning.
2. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. Molecular Biology of the Gene (7th Edition), Benjamin Cummings.
3. Alberts, B. et al. Molecular Biology of the Cell (7th Edition), W.W. Norton & Company.
4. Nelson, D. L. & Cox, M. M. Lehninger Principles of Biochemistry (8th Edition), W.H. Freeman.
5. Berg, J. M., Tymoczko, J. L., Gatto, G. J., & Stryer, L. Biochemistry (9th Edition), W.H. Freeman.
6. Strachan, T. & Read, A. P. Human Molecular Genetics (5th Edition), Garland Science.
7. Pevsner, J. Bioinformatics and Functional Genomics (4th Edition), Wiley-Blackwell.
8. Lesk, A. M. Introduction to Genomics (3rd Edition), Oxford University Press.
9. Gibson, G. A Primer of Genome Science (3rd Edition), Sinauer Associates / Oxford University Press.
10. Lodish, H. et al. Molecular Cell Biology (8th Edition), W.H. Freeman.

DISCIPLINE SPECIFIC CORE COURSE – DSC-10: BIOTECHNOLOGY FOR HUMAN HEALTH

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		
DSC-10: Biotechnology for Human Health	**04**	**03**	**01**	**0**	**B.Sc. Biochemistry and Allied Subjects**	**-**

Number of hours: 45 (T) + 15 (T)

Learning Objectives:

The course aims to provide fundamental insights to biological processes for the manufacturing of products that have industrial significance. It blends the principles from diverse science and engineering disciplines. The major focus of this course is on the industrial applications for students to gain practical knowledge with emphasis on major bottlenecks for the operation of biotechnology industries.

Learning Outcomes:

1. Students will be able to understand the fundamental principles of industrial biotechnology.
2. Students will be able to understand the importance of microbial, plant, and animal systems for the biotechnologically relevant products.
3. Students will be able to understand the drug discovery platforms and vaccine development technology and have an overview of the production side of these technologies beyond the discovery stages.
4. Students will be able to critically analyze any bioprocess from a market point of view.
5. Students will be able to apply this knowledge to examine the importance of microbial/enzymatic industrial processes in the food and fuel industry

Course Contents

Unit I: Introduction to Basics of Industrial Biotechnology, Microbes, Plant and Animal Based Biological Processes relevant to Industrial Biotechnology, Fundamental concepts of Biomanufacturing, Production of safe and effective biopharmaceuticals, Expression systems to produce biotherapeutics, Microbial growth, Microbial growth kinetics, High Density Microbial and eukaryotic fermentation for biomanufacturing, Role of Biochemistry in Ayurveda medicine

11 hours

Essential Reading-

Microbial Biotechnology: Technological Challenges and Developmental Trends. (2017). United States: Apple Academic Press. (Chapter- 17 & 18)
Microbial Biotechnology: Basic Research and Applications. (2020). Germany: Springer Nature Singapore. (Chapter 1 & 10)

Unit II: Concepts and research pipeline of drug discovery, various approaches such as high throughput virtual screening, structure-based drug design, rational drug design, repurposing of drugs, preclinical models, concepts of pharmacokinetics, trials, drug manufacturing, formulations and quality testing.

11 hours

Essential Reading-

1. Textbook of Drug Design and Discovery (5th Edition) — Edited by Kristian Strømgaard, Povl Krogsgaard-Larsen & Ulf Madsen, CRC Press (chapter 1, 4, 5)
2. Drug Design and Discovery: Methods and Protocols — Edited by Seetharama D. Satyanarayanajois. (chapter 1,2)
3. Fundamentals of Antimicrobial Pharmacokinetics and Pharmacodynamics. Edited by Alexander A. Vinks, Hartmut Derendorf, Johan W. Mouton (2014, 1st edition) (chapter 2,4)

Unit III : Vaccine Technology, vaccine production in laboratory and industry, vaccine pre-clinical models and its trials, Cytokine and hormone-based therapeutics, adjuvants, mechanism of action, types of adjuvants

12 hours

Essential Reading-

1. Novel Technologies for Vaccine Development. (2014). Austria: Springer Vienna. (Chapter-2 & 6)
2. Barrett, A. D., Stanberry, L. R. (2009). Vaccines for Biodefense and Emerging and Neglected Diseases. Netherlands: Elsevier Science. (Chapter- 4, 6 & 8)

Unit IV: Fundamental concepts of Antibody Engineering, Biosimilars, antibody conjugates for diagnostics and therapeutics, Recombinant antibody production and characterization for clinical use.

11 hours

Essential Reading-

1. Antibody Engineering: Methods and Protocols, Third Edition (2018) MIMB, volume 1827: Springer International Publishing. (Chapter- 1, 4, 6)
2. Introduction to Antibody Engineering. (2021) Springer International Publishing. (Chapter- 2, 5-10)

Tutorial **15 Hours**

1. Case study discussion on the manufacturing of one protein
2. Case study discussion on the manufacturing of one vaccine
3. Case study discussion on the manufacturing of one drug molecule/ hormone
4. Case study discussion on the manufacturing of one recombinant antibody

Recommended Readings:

1. Samuel Cate Prescott and Cecil Gordon Dunn. Industrial Microbiology: ISBN-10: 0333336305, Publisher: Palgrave Macmillan; 4th edition (1 May 1982)
2. Wulf Crueger and Anneliese Cruege, A textbook of Industrial Microbiology: ISBN-10: 9385998633, Publisher: Medtech (1 January 2017); scientific international
3. Bailey and Ollis, Biochemical Engineering Fundamentals: ISBN-10: 9780070701236, Publisher: McGraw Hill Education; 2nd edition (1 July 2017)
4. Blanch and Clark, Biochemical Engineering: ISBN-13: 979-0824700996, Publisher: T&F India (1 January 2007)
5. Antibody Engineering: Methods and Protocols, Third Edition (2018) MIMB, volume 1827: Springer International Publishing.
6. Introduction to Antibody Engineering. (2021) Springer International Publishing.

Suggested Reading-

1. Chen, G.Q. (2012). New challenges and opportunities for industrial biotechnology. *Microbial cell factories*, *11*(1), 111.

2. Yu, L.P., Wu, F.Q. & Chen, G.Q. (2019). Next-generation industrial biotechnology-transforming the current industrial biotechnology into competitive processes. *Biotechnology Journal*, *14*(9), 1800437.

3. Mesbah, N.M. (2022). Industrial biotechnology based on enzymes from extreme environments. *Frontiers in Bioengineering and Biotechnology*, *10*, 870083.

4. Textbook of Drug Design and Discovery (5th Edition) — Edited by Kristian Strømgaard, Povl Krogsgaard-Larsen & Ulf Madsen, CRC Press

5. Drug Design and Discovery: Methods and Protocols — Edited by Seetharama D. Satyanarayanajois.

6. Fundamentals of Antimicrobial Pharmacokinetics and Pharmacodynamics. Edited by Alexander A. Vinks, Hartmut Derendorf, Johan W. Mouton (2014, 1st edition)

DISCIPLINE SPECIFIC CORE COURSE – DSC-11: ADVANCED TECHNIQUES IN BIOCHEMISTRY

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		
DSC-11: Advanced Techniques in Biochemistry	**04**	**03**	**0**	**01**	**B.Sc. Biochemistry and Allied Subjects**	**-**

Number of hours: 45 (T) + 30 (P)

Course Objectives:

This course aims to provide students with in depth understanding of advanced experimental methodologies in cell biology, molecular biology, biophysical techniques, recombinant DNA technology, and genetic engineering. The course also trains students to effectively apply cloning, sequencing, and expression technologies in research and biotechnology on biosafety and regulatory compliance.

Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Demonstrate proficiency in advanced cell culture techniques, protein interaction, gene expression, silencing and post-translational modification assays.
2. Understand key molecular biology techniques including nucleic acid isolation, blotting, hybridization, and reporter assays.
3. Understand principles and applications of advanced biophysical techniques used in biological research.
4. Apply advanced molecular tools such as PCR, qPCR, mutagenesis, and sequencing for gene manipulation and expression studies, while adhering to biosafety regulations.
5. Critically analyze experimental data and integrate multidisciplinary approaches to address research questions in modern biotechnology.

Course Contents

Unit I: Cell biology: Introduction to mammalian cell culture techniques, including 2D and 3D culture systems. Principles and applications of cell immortalization, along with strategies for gene overexpression and gene silencing. Generation and characterization of transient and stable cell lines. Cell synchronization methods and cell cycle analysis using flow cytometry (FACS). Assessment of cell viability, cytotoxicity, apoptosis, proliferation, and assays for cell migration and invasion. Subcellular fractionation techniques and identification of cellular

compartments. Cell staining methods and immunofluorescence for visualization of cellular structures. Analysis of protein–protein interactions using pull-down and immunoprecipitation assays.

12 hours

Essential Readings:

1. Sambrook, J. & Russell, D. W. Molecular Cloning: A Laboratory Manual Vol I (4th Edition, Cold Spring Harbor Laboratory Press). Chapters- 16, 18, 17
2. K. Wilson and J. Walker. (2010) Principles and Techniques of Biochemistry and Molecular Biology (7th Edition), Cambridge University Press: Chapters: 2, 7 and 6
3. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell* (7th ed.). W. W. Norton & Company. Chapters 6,7,8, 9,12 and 17.
4. Ramkumar, K. M., Senthilkumar, R., & Hoque, Md Enamul (Eds.). (2023). *Advanced Mammalian Cell Culture Techniques: Principles and Practices*. CRC Press. Chapters 7,13, 14,15,21,23 and 25.

Unit II: **Molecular biology:** Isolation and analysis of plasmid DNA, genomic DNA, and RNA; gel electrophoresis for nucleic acid assessment. Principles and methodologies of Northern, Southern, and Western blotting for detecting nucleic acids and proteins. In situ hybridization for spatial gene expression analysis. In vitro transcription and translation assays for studying gene expression and protein synthesis. Electrophoretic Mobility Shift Assay (EMSA) and DNA footprinting for examining DNA-protein interactions, along with RNAse protection assays for transcript mapping. Chromatin immunoprecipitation (ChIP) and reporter assays for analyzing transcriptional regulation. Introduction to radioisotopes in biological research and essential laboratory safety practices for their proper handling.

12 hours

Essential Readings:

1. Sambrook, J. & Russell, D.W. Molecular Cloning: A Laboratory Manual Vol I (4th Edition, Cold Spring Harbor Laboratory Press). Chapters- Chapter 17, 5, 6, 7,8, 9, 18.
2. K. Wilson and J. Walker. (2010) Principles and Techniques of Biochemistry and Molecular Biology (7th Edition), Cambridge University Press: Chapters: 5,7,10 and 14

Unit III: Biophysical Techniques: CD spectroscopy, NMR spectroscopy, X-ray crystallography, Fluorescence and confocal microscopy, Cryo-electron microscopy, Isothermal Titration Calorimetry (ITC), Differential Scanning Calorimetry (DSC), Surface Plasmon Resonance (SPR), Bio-Layer Interferometry (BLI), Mass Spectrometry (MS), Analytical Ultracentrifugation (AUC), Dynamic Light Scattering (DLS), Small-Angle X-ray Scattering (SAXS), Förster Resonance Energy Transfer (FRET)

10 hours

Essential Readings:

1. K. Wilson and J. Walker. (2010) Principles and Techniques of Biochemistry and Molecular Biology (7th Edition), Cambridge University Press: Chapters: 3, 4, 8, 9, 12, 13.

2. Sheehan, D. (2009) Physical Biochemistry: Principles and Applications (2nd Edition), John Wiley & Sons: Chapters: 3, 4, 7, 8.

Unit IV: PCR and Sequencing Technologies: Principle, components, and optimization parameters; primer design and reaction setup; types of PCR — standard PCR, nested PCR, multiplex PCR, reverse transcription PCR (RT-PCR), and quantitative real-time PCR (qRT-PCR). Introduction to DNA and RNA sequencing; Sanger sequencing — principle, chain-termination method, chromatogram interpretation, and applications. Introduction to next-generation sequencing (NGS) — basic workflow and applications.

Essential Readings:

1. Sambrook, J. & Russell, D. W. — *Molecular Cloning: A Laboratory Manual* (4th Edition, Cold Spring Harbor Laboratory Press). Chapter 7-10.
2. Krebs, Jocelyn E., Goldstein, Stephen B., & Kilpatrick, Elliott W. — Lewin's GENES XII
3. (12th Edition, Jones & Bartlett Learning). Chapter 3

11 hours

Practicals **30 Hours**

1. Maintenance and subculturing of mammalian cells; cell counting and viability assays; apoptosis and proliferation assays; preparation of samples for flow cytometry and interpretation of FACS data.
2. Isolation of plasmid DNA and RNA; agarose gel electrophoresis; restriction digestion; PCR primer design, reaction setup, amplification and analysis; demonstration of RT- PCR/qRT-PCR data interpretation.
3. Immunoprecipitation and ELISA workflow demonstrations; exposure to DNA–protein interaction methods such as EMSA and ChIP (demonstration-based); interpretation of sequencing chromatograms.
4. Guided analysis of representative datasets from CD spectroscopy, DLS, ITC, SPR, and structural biology platforms to understand biomolecular interactions and structural properties.

Essential Readings:

1. Sambrook, J. & Russell, D.W. Molecular Cloning: A Laboratory Manual Vol I (4th Edition, Cold Spring Harbor Laboratory Press). Chapters- 16, 18, 17
2. K. Wilson and J. Walker. (2010) Principles and Techniques of Biochemistry and Molecular Biology (7th Edition), Cambridge University Press: Chapters: 2, 7 and 6
3. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell* (7th ed.). W.W. Norton & Company. Chapters 6,7,8, 9,12 and 17.
4. Ramkumar, K.M., Senthilkumar, R., & Hoque, Md Enamul (Eds.). (2023). *Advanced Mammalian Cell Culture Techniques: Principles and Practices*. CRC Press. Chapters 7,13, 14,15,21,23 and 25.
5. Krebs, Jocelyn E., Goldstein, Stephen B., & Kilpatrick, Elliott W. — Lewin's GENES
6. XII (12th Edition, Jones & Bartlett Learning).
7. Sheehan, D. (2009) Physical Biochemistry: Principles and Applications (2nd Edition), John Wiley & Sons: Chapters: 3, 4, 7, 8.

Suggested Readings:

1. G.M. Cooper. 2000. The Cell: Molecular Approach, ASM Press, Washington, D.C. USA.
2. J.R. Harris, J. M. Graham, D. Rickwood. (2006) Cell Biology Protocols. J Wiley and Sons Inc.
3. D. Sheehan. 2009. Physical Biochemistry: Principles and Applications (2nd Ed.), John Wiley and Sons Ltd, Chichester, England. ISBN: 978-0-470-85603-1.
4. J. Cavanagh, W.J. Fairbrother, A.G. Palmer III, M. Rance, N. J. Skelton. 2007. Protein NMR Spectroscopy: Principles and Practice, Academic Press, San Diego, USA. ISBN: 978-0-12-164491-8.
5. Advanced Biophysical Techniques in Biosciences. Editors: Nirmal Mazumder, Rajib Biswas, Guan-Yu Zhuo. Springer
6. Biophysical Techniques in Biochemistry and Molecular Biology – Van Holde & Johnson, Prentice Hall
7. Molecular Biophysics – Michel Daune, Oxford Univ. Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE-05: ADVANCED IMMUNOLOGY

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		
DSE-05: Advanced Immunology	04	03	01	0	-	-

Number of hours: 45 (H) + 15 (T)

Learning Objectives:

The objective of the course is to provide an insight into the components of the immune system, their development, their functions and their mechanisms of action as well as the diseases associated with defects or malfunctioning of the immune system. Further, applied aspects including vaccine development, antibody therapeutics and immunotherapy will be discussed.

Learning Outcomes:

1. Students will be able to describe the mechanisms used by the human body to fight foreign agents and disease-causing pathogens.
2. Students will be able to devise strategies to combat infection or diseases produced by altered self.
3. Students will develop ability to use this knowledge in the processes of immunization, antibody engineering, vaccine development, transplantation and cancer therapy.
4. Students will develop skill to use various techniques of immunology in research work.

Course Contents

Unit I: Introduction: Historical development of the branch "Immunology", Overview of the immune system, Molecules, cells and organs involved in immunity. Haematopoiesis, Innate immunity, adaptive immunity, Antigens, Immunogens, Haptens, Epitopes. Antigen-Antibody interactions, Discovery of immunoglobulins.

10 hours

Essential Readings:

1. J. Owen, J. Punt, S. Stranford, (2012) Kuby Immunology (8th Edition), WH Freeman and Company, USA Chapter – 1, 2, 3, 4
2. K. Murphy (2011) Janeway's Immunobiology (8th Edition), Garland Science, USA Chapters: 1, 2, 3, 4, 5, 6

Unit II: Adaptive Immune response: Humoral Immunity, Structure and function of various classes of immunoglobulins, Immunogenetics, Generation of antibody diversity, class switching among constant-region genes, B-cell activation and differentiation, B-cell receptor and the immunoglobulin superfamily, Generation of B cells, Responses, Immunological memory, Cell mediated immunity, MHC restriction and mechanism of antigen presentation, T- cell receptors, maturation, activation and differentiation, Generation of different types of T cells, Responses, Immunological memory.

15 hours

Essential Readings:

1. J. Owen, J. Punt, S. Stranford, (2012) Kuby Immunology (8th Edition), WH Freeman and Company, USA Chapter – 6, 7, 8, 9, 10, 11, 12, 13, 14
2. K. Murphy (2011) Janeway's Immunobiology (8th Edition), Garland Science, USA Chapters: 7, 8, 9, 10, 11.

Unit III: Immune effector mechanisms: Properties of cytokines, receptors, the complement systems, mechanism of complement activation, pathology related to complement proteins Allergy, Cell biology of hypersensitivity reactions, Tolerance, Mechanisms of induction of autoimmunity, treatment of autoimmune diseases.

10 hours

Essential Readings:

1. J. Owen, J. Punt, S. Stranford, (2012) Kuby Immunology (8th Edition), WH Freeman and Company, USA Chapter – 5, 15, 16
2. K. Murphy (2011) Janeway's Immunobiology (8th Edition), Garland Science, USA Chapters: 12, 13, 16.

Unit IV: Immune system in health and disease: Immunodeficiencies, AIDS, Transplantation immunology, Tumour antigens and cancer immunotherapy, Infections, Concepts of vaccines, whole-organism vaccines, recombinant vaccines, DNA vaccine, synthetic peptide and multivalent sub unit vaccines.

10 hours

Essential Readings:

1. J. Owen, J. Punt, S. Stranford, (2012) Kuby Immunology (8th Edition), WH Freeman and Company, USA Chapter – 16, 17, 18, 19, 20
2. K. Murphy (2011) Janeway's Immunobiology (8th Edition), Garland Science, USA Chapters: 13, 14, 15, 16.

Tutorial **15 Hours**

1. Applications of antibodies in diagnostics and routine laboratory assay systems.
2. Principles of Agglutination, western blot, radioimmunoassay, ELISA, immunohistochemistry.
3. Flow cytometry for immunocytes identification and purification, visit to facility for demonstration of instrument and analysis of FACS data.
4. Development of monoclonal antibodies and their applications

Suggested Readings:

1. J. Owen, J. Punt, S. Stranford, (2012) Kuby Immunology (8th Edition), WH Freeman and Company, USA.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. (2012) Biochemistry (7th Edition), WH Freeman and Company, USA.
3. D. Male, J. Brostoff, D. Roth, I. Roitt, (2012) Immunology (8th Edition), Saunders, Elsevier, USA.
4. K. Murphy (2011) Janeway's Immunobiology (8th Edition), Garland Science, USA.
5. A. Abbas, A. Lichtman, S. Pillai, (2014) Cellular and Molecular Immunology (8th Edition), Saunders, Elsevier, USA.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE-06: BIOSAFETY, BIOETHICS AND BIOSECURITY

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		
DSE-06: Biosafety, Bioethics and Biosecurity	**04**	**03**	**01**	**0**	**-**	**-**

Number of hours: 45 (H) + 15 (T)

Learning Objectives:

This course aims to introduce the concepts of biosafety and biosecurity to the students. The course will delve into bringing the students out of the theoretical concepts and enable them to design a research lab, draft SOPs, perform risk assessment, be prepared for emergencies. Students will be taught the importance of sensitive agents, information and assets along with implementation of measures to mitigate biological untoward incidents.

Learning Outcomes

On successful completion of this course, students will be able to:

1. Understand the principles and practices of biosafety and biosecurity in biomedical research.
2. Understand the considerations and how to perform risk assessment while designing a new research lab or facility
3. Evaluate ethical considerations in conducting research involving hazardous organisms or having dual-use implications
4. Understand biorisk management system and its components.
5. Foster research responsibly, ethically, and help build an innovation culture towards it.

Course Contents

Unit I: Introduction to Biosafety, Biosecurity and Bioethics, historical perspectives, global and national scenarios and landscapes, Biological risk groups and biosafety levels, video demonstrations and video tour of various biosafety level labs, safe handling practices and procedures for pathogens, GMOs, toxins etc. Rules for the manufacture, use, import, export & storage of hazardous microorganisms, GE organisms or cells, 1989.

11 Hours

Essential Reading

1. Biosafety in Microbiological and Biomedical Laboratories 6th Edition. Centers for Disease Control and Prevention, National Institutes of Health (section I, III)
2. Laboratory Biorisk Management: Biosafety & Biosecurity (edited by Salerno & Gaudioso) – chapter 1

Unit II: Preparation of SOPs and layout for fictitious BSL3/BSL4 labs, role of protective barriers (PPE, biosafety cabinets), waste management, decontamination and disposal guidelines, safety measures and emergency protocols, Biosafety mock drills and their importance, gain-of-function research, risk assessment, biosafety incidents, its mitigation and emergency measures. Case studies to discuss disease outbreaks with respect to biosafety aspects. ABSL3 biosafety practices, IAEC and CCSEA guidelines for animal handling. ICMR guidelines for working with human samples.

12 Hours

Essential Reading

1. Biosafety in Microbiological and Biomedical Laboratories 6th Edition. Centers for Disease Control and Prevention, National Institutes of Health (section II)
2. Laboratory Biorisk Management: Biosafety & Biosecurity (edited by Salerno & Gaudioso) – chapter 1, 11

Unit III: Importance of Biosecurity awareness, assets, threats, risk, eights pillar of biosecurity, biorisk management system and its elements, risk assessment framework, Dual-use research of concern (DURC), likelihood, consequences

10 Hours

Essential Reading

1. Biosafety in Microbiological and Biomedical Laboratories 6th Edition. Centers for Disease Control and Prevention, National Institutes of Health (section VI)
2. WHO Laboratory biosecurity guidance 2024. (chapter 4,5,6)

Unit IV: Preparation of biosecurity SOPs for fictitious labs/situations, concepts of risk tolerance, mitigation measures, emergency preparedness, innovation in reporting and research culture, biosecurity mock drills, Principles of bioethics, ethics of genetic engineering and stem cell research, policy frameworks (WHO, CDC, NIH, RCGM, IBSC).

12 Hours

Essential Reading:

1. Handbook for Institutional Biosafety Committees (IBSCs) by Department of Biotechnology Ministry of Science & Technology, Government of India (Third Revised Edition September, 2020) – chapter 1,2,3
2. Biosafety in Microbiological and Biomedical Laboratories 6th Edition. Centers for Disease Control and Prevention, National Institutes of Health (section II)

Tutorial **15 Hours**

1. Case studies - disease outbreaks and importance of biosafety
2. Discussion of various biosafety SOPs (BMBL, NIH etc.)
3. Group discussion – how to enhance biosafety/biosecurity awareness and measures
4. Performing a mock risk assessment study

Suggested Readings

1. Biosafety in Microbiological and Biomedical Laboratories 6th Edition, Centers for Disease Control and Prevention National Institutes of Health
2. Handbook for Institutional Biosafety Committees (IBSCs) by Department of Biotechnology Ministry of Science & Technology, Government of India
3. Laboratory biosecurity guidance, WHO (June 2024) https://www.who.int/publications/i/item/9789240095113#:~:text=Overview,responsibility%20of%20institutional%20biosafety%20committees
4. A guide for the practical implementation of the WHO LABORATORY BIOSAFETY MANUAL FOURTH EDITION, WHO (February 2024). https://www.who.int/publications/i/item/9789290211051

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE-07: PRINCIPLES IN GENETICS

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		
DSE-07: Principles in Genetics	**04**	**03**	**0**	**01**	**B.Sc. Biochemistry and Allied Subjects**	**-**

Number of hours: 45 (T) + 30 (P)

Learning Objectives:

This course aims to introduce students to the fundamental and advanced concepts of genetics, emphasizing both classical and molecular perspectives. It will provide a strong foundation in Mendelian and non-Mendelian inheritance, gene mapping techniques, microbial and human genetics, and the molecular mechanisms underlying mutation and recombination. The course will also integrate quantitative genetics and explore the genetic basis of complex traits and diseases, enabling students to understand how genetic variation contributes to phenotypic diversity and inheritance patterns.

Learning Outcomes

On successful completion of the course, students will be able to:

- Explain classical and non-Mendelian inheritance patterns and analyze genetic crosses.
- Apply gene mapping techniques to study linkage, recombination, and chromosomal abnormalities.
- Understand microbial genetic mechanisms and their applications in gene transfer and analysis.
- Interpret human pedigrees, karyotypes, and identify major genetic disorders.
- Describe the molecular basis and consequences of mutations, recombination, and quantitative trait inheritance.

Course Contents

Unit I: Mendelian principles—dominance, segregation, independent assortment. Concept of gene: allele, multiple alleles, pseudoallele, complementation tests. Extensions of Mendelian principles: codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity.

12 Hours

Essential Readings:

Griffiths et al., *Introduction to Genetic Analysis*, 11th Edition (W.H. Freeman), Chapter 2, 3, 6

Klug, Cummings, Spencer, & Palladino – *Concepts of Genetics*, 12th Edition (Pearson), Chapter 3,4

Unit II: Structural and numerical alterations of chromosomes: deletion, duplication, inversion, translocation, ploidy and their genetic implications. Recombination: homologous and non-homologous recombination.

12 Hours

Essential Readings:

Klug, Cummings, Spencer, & Palladino – *Concepts of Genetics*, 12th Edition (Pearson) Chapter 6

Griffiths et al., *Introduction to Genetic Analysis*, 11th Edition (W.H. Freeman**)** Chapter 15,16

Unit III: Linkage and crossing over. Gene mapping methods: linkage maps, tetrad analysis, mapping with molecular markers. Human genetics: pedigree analysis, LOD score for linkage testing, karyotyping, genetic disorders, GWAS studies

11 Hours

Essential Readings:

Hartl & Ruvolo – *Genetics: Analysis of Genes and Genomes*, 8th Edition Chapter 4, 6, 7

Klug, Cummings, Spencer, & Palladino – *Concepts of Genetics*, 12th Edition (Pearson) Chapter 7, 8, 15, 26

Unit IV: Quantitative genetics: polygenic inheritance, heritability and its measurements, QTL mapping. Mutation: types, causes and detection, mutant types—lethal, conditional, biochemical, loss of function, gain of function, germinal versus somatic mutants, insertional mutagenesis.

10 Hours

Essential Readings:

Klug, Cummings, Spencer, & Palladino – *Concepts of Genetics*, 12th Edition (Pearson) Chapter23, 25

Hartl & Ruvolo – *Genetics: Analysis of Genes and Genomes*, 8th Edition, Chapter 12, 13, 16

Practical **30 Hours**

1 Study and analysis of Mendelian and non-Mendelian inheritance patterns through monohybrid and dihybrid crosses, test cross analysis, and problem-based determination of genotypic and phenotypic ratios.
2. Demonstration and identification of chromosomal abnormalities using karyotypes/idiograms; study of structural and numerical chromosomal alterations such as deletion, duplication, inversion, translocation, aneuploidy, and polyploidy through case-based analysis.
3. Construction and analysis of pedigree charts and linkage maps, including identification of modes

of inheritance, estimation of recombination frequency, and basic LOD score calculation for linkage analysis.

4. Calculation and interpretation of quantitative genetic parameters, including problems on polygenic inheritance, estimation of heritability, basic QTL mapping exercises, and classification/analysis of different types of mutations.

Suggested Readings:

1. Griffiths et al. – Introduction to Genetic Analysis, 11th Edition (W.H. Freeman)
2. Klug, Cummings, Spencer & Palladino – Concepts of Genetics, 12th Edition (Pearson)
3. Hartl & Ruvolo – Genetics: Analysis of Genes and Genomes, 8th Edition (Jones & Bartlett Learning)
4. Snustad & Simmons – Principles of Genetics, 7th Edition (Wiley)
5. Pierce, Benjamin A. – Genetics: A Conceptual Approach, 7th Edition (Macmillan)
6. Russell, P. – iGenetics: A Molecular Approach, 3rd Edition (Pearson)
7. Brooker, R. J. – Genetics: Analysis and Principles, 6th Edition (McGraw-Hill)
8. Milner et al. – Essential Genetics and Genomics, 7th Edition (Oxford University Press)

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE-08: ADVANCED PROTEOMICS AND METABOLOMICS

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		
DSE-08: Advanced Proteomics and Metabolomics	**04**	**03**	**0**	**01**	**-**	**-**

Number of hours: 45 (H) + 30 (P)

Learning Objectives:

The course aims to provide detailed knowledge about the concepts and applications of proteomics and metabolomics and about mass spectrometry. This course emphasizes on the advancement from protein chemistry to the field of proteomics. The methodology and the instrumentation involved in conducting experiments to proteomics and metabolomics are discussed in the course.

Learning Outcomes

On successful completion of the course, students will be able to:

1. Explain the principles and methodologies of proteomics, and metabolomics. Importantly, they will be able to learn the benefits of using proteomics and metabolomics tools over other approaches.
2. Demonstrate understanding of multi-omics data generation, analysis workflows, and data integration strategies.
3. Interpret biological significance through pathway and network analysis using real datasets.
4. Critically analyze published proteomics and metabolomics studies and identify their relevance in disease biology and biotechnology.
5. Gain a detailed knowledge of mass spectrometry along with its various components and its applicability in proteomics and metabolomics.

Course Contents

Unit I: Introduction to proteome, proteomics technology, types and kinds of proteomics investigation, overview of systems biology, evolution from protein chemistry to proteomics, importance of proteomics. Quantitation proteomics, Interaction Proteomics, Structural and functional proteomics. Protein Extraction and Sample Preparation- sample collection and lysis methods, solubilization, digestion and reduction/alkylation of proteins, quantification, cleanup

and desalting for MS analysis. Two-dimensional gel electrophoresis (2-DE), 2D-DIGE, Merits and demerits of gel-based proteomics. Chromatographic methods, MudPIT.

10 Hours

Essential Reading:

1. Srivastava, S. (2023) From Proteins to Proteomics. Basic concepts, techniques and Applications. Sanjeeva Srivastava, 2023, CRC Press, Taylor & Francis Ltd. (Chapter 1,2)

Unit II: Mass spectrometry (Ionizers, analyzers and detectors) technology, Principles of ionization and mass detection. Ionization methods: ESI, MALDI. Mass analyzers: Quadrupole, Ion-traps, TOF, Q-TOF, Orbitrap. Tandem MS (MS/MS) and fragmentation methods. ICAT, SILAC, iTRAQ, data-dependent and data-independent acquisition, SWATH, targeted proteomics, nanopore-based proteomics. Understanding proteomics for PTM analysis. Proteomics for protein-protein interactions: from conventional Y2H to proteomic scale Y2H, protein microarrays and interactomics, Tandem affinity purification.

12 Hours

Essential Reading:

1. Srivastava, S. (2023) From Proteins to Proteomics. Basic concepts, techniques and Applications. Sanjeeva Srivastava, 2023, CRC Press, Taylor & Francis Ltd. (Chapter 3)
2. Gross, Juergen H; Roepstorff, Peter (2011, 2nd edition). Mass Spectrometry: A Textbook, Springer (chapter 4,5)

Unit III: Data analysis – database searching: MASCOT, MAxQuant, SEQUEST, Protein databases: UniProt, PDB, PRIDE, PeptideAtlas. Data normalization, FDR, and statistical validation. Functional annotation tools: DAVID, STRING, Cytoscape. Application of proteomics for drug discovery, Biomarker discovery, drug targets identification, Validation of drug targets, toxicological assessment and personalized medicine. Emerging Technologies and Trends –Single cell proteomics, top-down proteomics, Immunopeptidomics, AI in proteomics.

12 Hours

Essential Reading:

1. Statistical Analysis of Proteomics, Metabolomics, and Lipidomics Data Using Mass Spectrometry by Bart J. A. Mertens, Susmita Datta (2016) (chapter 6,7)
2. Immunoproteomics: Methods and Protocols by Kelly M. Fulton, Susan M. Twine. Springer protocols (Third edition, 2026) chapter 2

Unit IV: Introduction to metabolomics world. Historical perspectives. Targeted vs untargeted metabolomics; metabolite extraction strategies, Metabolite profiling, metabolic fingerprinting and biomarker discovery, Introduction to systems biology: data processing, statistical methods (PCA, clustering), metabolite identification databases: METLIN, HMDB, network analysis, metabolic modeling, and pathway integration, Applications in disease biology, nutrition, and personalized medicine.

11 Hours

Essential Reading:

1. Alessandra Sussulini (2017). Metabolomics: From Fundamentals to Clinical Applications Springer (chapter 1,4)
2. Raúl González-Domínguez (2023) Mass Spectrometry for Metabolomics. Humana Press (chapter 6,7,2021)

Tutorial **15 Hours**

1. Case study discussions on sample preparation and experimental design on published multi-omics datasets spanning proteomics, and metabolomics.
2. Retrieving datasets from published repositories such as GEO**,** PRIDE, and the Metabolomics Workbench
3. Visit to Mass-spectrometry facility, equipment demonstration and Hands-on data analysis using various proteomics tools
4. Group discussion and analysis of metabolomics data

Suggested Readings

1. Srivastava, S. (2023) From Proteins to Proteomics. Basic concepts, techniques and Applications. Sanjeeva Srivastava, 2023, CRC Press, Taylor & Francis Ltd.
2. Gross, Juergen H; Roepstorff, Peter (2011, 2nd edition). Mass Spectrometry: A Textbook, Springer
3. Immunoproteomics: Methods and Protocols by Kelly M. Fulton, Susan M. Twine. Springer protocols (Third edition, 2026)
4. Alessandra Sussulini (2017). Metabolomics: From Fundamentals to Clinical Applications Springer
5. Raúl González-Domínguez (2023) Mass Spectrometry for Metabolomics. Humana Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE-09: DISEASE MODELS AND CLINICAL 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		
DSE-09: Disease Models and Clinical Research	04	03	01	0	-	-

Number of hours: 45 (H) + 15 (T)

Learning Objectives:

This course aims to introduce students to the use of model organisms in biomedical research and the foundational principles of clinical research. It focuses on how disease models are established, validated, and translated into clinical applications. Students will explore ethical and regulatory frameworks, understand the design of clinical trials, and gain insights into biomarker discovery and personalized medicine through real-world case studies and data- driven analysis.

Learning Outcomes

On successful completion of this course, students will be able to:

1. Explain the rationale for using specific model organisms in studying human diseases.
2. Analyze the design, phases, and regulatory aspects of clinical trials.
3. Evaluate ethical considerations in animal and human studies, including CPCSEA and ICMR guidelines.
4. Interpret clinical trial data and assess the translational relevance of disease models.
5. Identify potential diagnostic and prognostic biomarkers from experimental and clinical datasets.

Course Contents

Unit I: Introduction to Disease Models. Definition and importance of model organisms in biomedical research; Criteria for model selection; Overview of in vitro, ex vivo, and in vivo models; Transgenic and knockout animal models; Ethical considerations in animal research (CPCSEA guidelines); Alternatives to animal models.

12 Hours

Essential Reading:

1. Animal Models in Research- Principles and Practice. Editors- Harikrishnan Vijayakumar Sreelatha, Satish Patel, Perumal Nagarajan (2024), Springer (chapter 1, 2, 5)

2. Animal Models for the Study of Human Disease, P. Michael Conn. Academic Press (2nd edition) (chapter 1)

Unit II: Experimental Disease Models and Applications. Models of infectious diseases; Cancer models; Metabolic disorders; neurodegenerative disease models; Inflammatory and autoimmune disease models; Toxicological models for drug safety evaluation. In vitro and in vivo models for pharmacokinetics of drug candidates.

12 Hours

Essential Reading:

1. Rodent Models of Neurodegenerative Disease, Edited by Pegah Javadpour, Sahar Askari, Rasoul Ghasemi, (1st edition, 2026) CRC Press (chapter 1,3)
2. Handbook of Animal Models and its Uses in Cancer Research, edited by Surajit Pathak, Antara Banerjee, Atil Bisgin (1st edition), Springer (chapter 2,8)

Unit III: Basics of Clinical Research and Study Design. Importance of clinical research, phases of clinical trials (I–IV); Types of study designs—observational, interventional, randomized controlled trials, cohort and case-control studies; Blinding and randomization; Informed consent and ethical clearance; Data collection, monitoring, and adverse event reporting; Good Clinical Practices (GCP); Role of Institutional Ethics Committees and regulatory authorities (ICMR, CDSCO, WHO, DCGI, FDA, EU).

11 Hours

Essential Reading:

1. Fundamentals of Clinical Trials. Editors - Lawrence M. Friedman, Curt D. Furberg, David L. DeMets, David M. Reboussin, Christopher B. Granger. (2015) Springer (chapter 1, 2, 5, 6)

Unit IV: Translational Research. Translational pipeline from bench to bedside; Concepts of drug discovery, vaccine design, and biomarker discovery. Concepts of personalized and precision medicine; Preclinical to clinical transition—challenges and strategies; Role of biomarkers in diagnosis, prognosis, and therapy response; Companion diagnostics; Case studies on translational success stories in oncology, infectious diseases, and metabolic syndromes.

10 Hours

Essential Reading:

1. Translational Medicine. The future of therapy. Editors -James Mittra, Christopher-Paul Milne (2013) CRC Press (chapter 1, 3, 6,7)

Tutorial **15 hours**

1. Case-based discussions on model organisms in studying cancer and metabolic diseases.
2. Case-based discussions on model organisms in studying infectious diseases.
3. Clinical trial protocol evaluations, review ethical documentation including CPCSEA formats, and explore the principles of the 3Rs.
4. Group discussions analyzing translational success stories and challenges in clinical research.

Suggested Readings

1. Animal Models for the Study of Human Disease, P. Michael Conn. Academic Press (2nd edition)
2. Animal Models in Research- Principles and Practice. Editors- Harikrishnan Vijayakumar Sreelatha, Satish Patel, Perumal Nagarajan (2024), Springer
3. Fundamentals of Clinical Trials. Editors - Lawrence M. Friedman, Curt D. Furberg, David L. DeMets, David M. Reboussin, Christopher B. Granger. (2015) Springer
4. Translational Medicine. The future of therapy. Editors -James Mittra, Christopher-Paul Milne (2013) CRC Press
5. Rodent Models of Neurodegenerative Disease, Edited by Pegah Javadpour, Sahar Askari, Rasoul Ghasemi, (1st edition, 2026) CRC Press
6. Handbook of Animal Models and its Uses in Cancer Research, edited by Surajit Pathak, Antara Banerjee, Atil Bisgin (1st edition), Springer

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE-10:
AI AND ITS APPLICATIONS IN BIOMEDICINE AND BIOTECHNOLOGY

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		
DSE-10: AI and its applications in Biomedicine and Biotechnology	**04**	**03**	**0**	**01**	**B.Sc. Biochemistry and Allied Subjects**	**-**

Number of hours: 45 (T) + 30 (P)

Learning Objectives:

The primary objective of this course is to introduce postgraduate students to the fundamental concepts of artificial intelligence and machine learning. This course will help them understand how AI-based solutions are strengthening human healthcare, biomedical research, and their potential to change clinical decisions. The integration of machine learning- based artificial intelligence in healthcare is transforming the way medical professionals diagnose, treat, and manage patients. This course will cover topics such as the basics of artificial intelligence and its integration with human health, machine learning algorithms, medical imaging, personalized medicine, and ethical regulations. Students will be encouraged for group case studies, hands-on experience, and guest lecturers to explore the opportunities and challenges to apply their knowledge to transform human health with minimal risk.

Learning Outcomes:

1. Students will be able to get hands-on experience with AI tools and platforms through practical exercises and projects.
2. Students will be able to experience the fundamentals of artificial intelligence and machine learning and their applications in medicine.
3. Students will be able to hands on experience of AI in medical imaging, diagnostics, disease prediction, treatment planning and transforming them to make digital health.
4. Students will be able to apply analytical knowledge to examine the ethical, legal, and social implications of AI in medicine, including issues of bias, privacy, and equity.

Course Contents

Unit I: Basic concepts of Artificial Intelligence, machine learning and deep learning, generative AI, Definition and scope of AI in healthcare, Historical perspective and milestones in AI research, Applications of AI in clinical practice, biomedical research and agriculture.

11 hours

Essential Reading-

Future of AI in Biomedicine and Biotechnology. (2024). United States: IGI Global. (Chapter- 1 & 2)
Artificial Intelligence-Based System Models in Healthcare. (2024). United Kingdom: Wiley. (Chapter- 2 & 6)

Unit II: Supervised, semi-, and unsupervised learning, Big data, Neural networks (ANN, CNN and RNN), feature selection and dimensionality reduction (PCA, t-SNE), digital health, model building, and evaluation of clinical datasets and data handling.

11 hours

Essential Reading-

Future of AI in Biomedicine and Biotechnology. (2024). United States: IGI Global. (Chapter- 2 & 4)
Artificial Intelligence-Based System Models in Healthcare. (2024). United Kingdom: Wiley. (Chapter- 2, 4 & 6)

Unit III: AI in Medical Imaging, Radiology, histopathology and quantitative imaging biomarkers, AI for data analytics and data mining, AI for omics data analysis, AI in Diagnostics and Disease Prediction, Diagnostic decision support systems, predictive models – protein structure prediction, protein-protein interactions

11 hours

Essential Reading-

Future of AI in Biomedicine and Biotechnology. (2024). United States: IGI Global. (Chapter- 2 & 4)
Artificial Intelligence-Based System Models in Healthcare. (2024). United Kingdom: Wiley. (Chapter- 2, 4 & 6)

Unit IV: AI in Personalized Medicine and Treatment Planning, Drug discovery, virtual screening, QSAR, prediction of drug-target interactions, and repurposing using AI approaches, Ethical, Legal, and Social Implications of AI in Medicine, Bias and fairness in AI algorithms, Privacy and security of healthcare data, Regulation and policy considerations for AI in healthcare. Opportunities and challenges in using AI.

12 hours

Essential Reading-

Future of AI in Biomedicine and Biotechnology. (2024). United States: IGI Global. (Chapter- 2 & 4)
Artificial Intelligence-Based System Models in Healthcare. (2024). United Kingdom: Wiley. (Chapter- 2, 6 & 8)

Practical **30 Hours**

1. Data analysis and group activity for diagnostic prediction of human diseases
2. AI based small group projects to identify inhibitors against specific disease
3. Group activity of ML modeling and data analysis on biological datasets
4. Group activity on AI based clinical algorithm for ethical regulations

Recommended Readings:

1. Stuart Russell and Peter Norvig. (2009). Artificial Intelligence: A Modern Approach (3rd ed.). Prentice Hall Press, Upper Saddle River, NJ, USA.
2. Tony J. Cleophas and Aeilko H. Zwinderman. (2015). Machine Learning in Medicine - a Complete Overview. Springer.
3. V.K. Prajapati. (2024), Volume 139: Translational Bioinformatics, Advances in Protein Chemistry and Structural Biology. ISBN: 978-0-443-19348-4, Academic Press Inc
4. Peter Harrington. (2012). Machine Learning in Action. Manning Publications Co., Greenwich, CT, USA.

Suggested Reading-

Altara, R., Basson, C.J., Biondi-Zoccai, G., & Booz, G.W. (2024). Exploring the promise and challenges of artificial intelligence in biomedical research and clinical practice. *Journal of cardiovascular pharmacology*, *83*(5), 403-409.

Blasimme, A., & Vayena, E. (2019). The ethics of AI in biomedical research, patient care and public health. *Patient Care and Public Health (April 9, 2019). Oxford Handbook of Ethics of Artificial Intelligence, Forthcoming*.

Bali, J., Garg, R., & Bali, R.T. (2019). Artificial intelligence (AI) in healthcare and biomedical research: Why a strong computational/AI bioethics framework is required? *Indian journal of ophthalmology*, *67*(1), 3-6.

SKILL BASED COURSE (SEC-RM)
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		
SEC-RM: Advanced Research Methodology	**02**	**01**	**0**	**01**	**B.Sc. Biochemistry and Allied Subjects**	**-**

No. of hours: 15 (T) + 30 (P)

Learning Objectives:

The course aims to build foundational knowledge of research principles, biosafety, and ethics while training students to identify research problems, design experiments, and analyze data. It will help the students develop skills in scientific writing, referencing, plagiarism avoidance, and effective oral and poster presentation.

Learning Outcomes:

Upon successful completion of this course, students will be able to:

- Understand fundamental research principles, biosafety guidelines, and ethical standards governing scientific investigations.
- Identify and define a research problem through effective literature review and source evaluation.
- Design and execute experiments using appropriate methodologies, tools, and data validation techniques.
- Analyze, interpret, and document scientific data with accuracy and clarity.
- Communicate research effectively through professional writing, referencing, and oral/poster presentations.

Unit 1: Research Foundations, Ethics, and Biosafety

Comprehensive introduction to the principles underlying responsible and safe scientific research. Biosafety and bioethics guidelines, laboratory safety practices, radioactive and fire safety, biowaste management, and the handling of genetically modified organisms. Institutional biosafety and animal ethics compliance. Introduction to significance of research, identification of research problems, experimental design and execution, method selection, data validation, and scientific communication, referencing, and presentations. Research publication ethics.

7 hours

Essential Readings:

1. Thomas, C. G. (2021). Research Methodology and Scientific Writing. Germany: ANE Books Pvt. Limited. (Chapters: 1, 7, 8, 9, 10, 23)
2. Scientific Methods Used in Research and Writing. (2020). United Kingdom: CRC Press. (Chapters: 1 and 4)
3. Research paper: Steneck, N. H. (2006). Fostering integrity in research: Definitions, current knowledge, and future directions. Science and Engineering Ethics, 12(1), 53–74.
4. Kothari, C. R.; Garg, G. Research Methodology: Methods and Techniques (New Age
5. International, 2019). Chapters: 1, 2 and 3

Unit 2: Intellectual Property Rights& Entrepreneurship

Introduction to entrepreneurship and intellectual property: Definition, concepts, Innovation, invention and creativity, Patents, copyright and trademarks, patentable and non-patentable, Patent Databases, Searching a patent, Types of patent applications, Incubators, research parks, Various Government policies, Technology Transfer

8 hours

Essential Readings:

1. Narayanan, V. K., Managing technology and innovation for competitive advantage, first edition, Pearson education, New Delhi, (2006)
2. Idris, K. (2003), Intellectual property: a power tool for economic growth, second edition, WIPO publication no. 888, Switzerland.
3. http://www.wipo.int/patents/en/

8 hours

Practicals: **30 Hours**

1. Oral presentation
2. Poster presentation
3. Patent Search using online databases
4. Visit to Industry/ incubator set-up

Essential Readings:

1. Thomas, C.G. (2021). Research Methodology and Scientific Writing. Germany: ANE Books Pvt. Limited.
2. Scientific Methods Used in Research and Writing. (2020). United Kingdom: CRC Press.
3. Research paper: Steneck, N.H. (2006). Fostering integrity in research: Definitions, current knowledge, and future directions. Science and Engineering Ethics, 12(1), 53–74.
4. Kothari, C.R.; Garg, G. Research Methodology: Methods and Techniques (New Age International, 2019).
5. Narayanan, V. K., Managing technology and innovation for competitive advantage, first edition, Pearson education, New Delhi, (2006)
6. Idris, K. (2003), Intellectual property: a power tool for economic growth, second edition, WIPO publication no. 888, Switzerland.
7. http://www.wipo.int/patents/en/

Suggested Readings:

1. Cresswell, J. (2009). Research Design: Qualitative and quantitative Approaches Thousand Oaks CA, (3rd ed.), Sage Publications
2. Kothari, C.R. (2004). Research Methodology: Methods and Techniques (2nd ed.), New Age International Publishers.
3. Kumar, R. (2011). Research Methodology: A Step-by-Step Guide for Beginners (5th ed.), SAGE publisher
4. Walliman, N. (2017). Research Methods: The Basics, (2nd ed.), London; New York: Routledge
5. WHO. (2001). Health Research Methodology – A Guide for Training in Research Methods.

SKILL BASED COURSE – SBC-3 :
TOOLS FOR BIOSTATISTICS AND DATA VISUALIZATION

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		
SBC-3: Tools for Biostatistics and Data Visualization	**02**	**0**	**0**	**02**	**B.Sc. Biochemistry and Allied Subjects**	**-**

Number of hours: 60 (P)

Learning Objectives:

To provide students with a conceptual and practical understanding of biostatistical methods and graphical data representation used in biological research, enabling accurate analysis, interpretation, and presentation of experimental data.

Unit I

Hands-on training in basic biostatistics, including types of data and variables, measures of central tendency and dispersion, probability and normal distribution, and graphical representation of data using histograms, bar diagrams, and frequency polygons. Practical exercises will include experimental design, sampling, hypothesis testing, and application of parametric and non-parametric tests including t-test, ANOVA, and Chi-square test, along with correlation and regression analysis using biological datasets.

35 Hours

Essential Readings:

- Glantz, S.A. (2012). *Primer of Biostatistics*, 7th Edition, McGraw-Hill — Chapter 2: How to Summarize Data**.**
- Glantz, S.A. (2012). *Primer of Biostatistics*, 7th Edition, McGraw-Hill — Chapter 4: The Special Case of Two Groups: The t Test**.**
- Motulsky, H. (2018). Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking, 4th Edition, Oxford University Press — Chapters 15–21: P Values and Statistical Significance, Chapter 32: Correlation, Chapter 33: Simple Linear Regression.

Unit II:

Hands-on training in scientific visualization and presentation of biological data using GraphPad Prism, Microsoft Excel, and R (ggplot2), including bar plots, box plots, scatter plots, violin plots, pie charts, heatmaps, volcano plots, and Venn diagrams. Practical exercises will also include interpretation and reporting of statistical results, presentation of data in figures and tables, reproducibility, ethical data handling, and case studies from published biological research.

25 Hours

Essential Readings:

- Wickham, H. (2016). ggplot2: Elegant Graphics for Data Analysis, 2nd Edition, Springer — Chapter 1: Preface, Chapter 3: Mastering the grammar, Chapter 4: Build a plot layer by layer, Chapter 8: Polishing your plots for publication.
- Manisha, N., 2020. Advanced Analytics with Excel 2019. BPB Publications. Chapter 4: Data Visualization with New Chart types.
- Glantz, S.A. (2012). Primer of Biostatistics, 7th Edition, McGraw-Hill — Chapter 12: What Do the Data Really Show?
- Motulsky, H. (2018). Intuitive Biostatistics, 4th Edition, Oxford University Press — Chapter 44 – 48: Putting It All Together.

Suggested Readings

1. Glantz, S.A. (2012). *Primer of Biostatistics*, 7th Edition, McGraw-Hill Education, New York.
2. Motulsky, H. (2018). *Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking*, 4th Edition, Oxford University Press, New York.
3. Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*, 2nd Edition, Springer-Verlag, New York.
4. Manisha, N. (2020). *Advanced Analytics with Excel 2019*, BPB Publications, New Delhi.
5. Khan, I.A. & Khanum, A. (2018). *Fundamentals of Biostatistics*, 4th Edition, Ukaaz Publications, Hyderabad.
6. Rosner, B. (2016). *Fundamentals of Biostatistics*, 8th Edition, Cengage Learning, Boston.
7. Sokal, R.R. & Rohlf, F.J. (2012). *Biometry: The Principles and Practice of Statistics in Biological Research*, 4th Edition, W.H. Freeman, New York.
8. Zar, J.H. (2010). *Biostatistical Analysis*, 5th Edition, Pearson Education, New Delhi.

SKILL BASED COURSE – SBC-4 : SCIENTIFIC 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		
SBC-4: Scientific Research Writing	**02**	**0**	**0**	**02**	**B.Sc. Biochemistry and Allied Subjects**	**-**

Number of hours: 60 (P)

Learning Objectives:

This course is designed to introduce students to basic scientific writing skills. Participants will review the general principles of clear, persuasive writing, and will apply these principles to writing for a scientific audience. Particular emphasis will be placed on conveying the significance of your research, outlining the aims, and discussing the results for scientific papers and grant proposals. The course will also provide an overview of the structure and style of research grant proposals and scientific manuscripts

Learning Outcomes

On successful completion of this course, students will be able to:

1. Understand the process of scientific writing
2. Explain the importance and application of current trends for manuscript and research grants
3. Understand the nature of figures, tables, and graphs and their use for scientific writing

Course Contents

Unit I: Introduction-Overview of science writing, discussion on how is scientific writing different from general writing, knowing your audience and readership. Writing exercises for general public, science reporting, Science news, explanatory writing, lengthy magazine article, popular articles and popular lectures. Collation of reading material: Popular science magazine articles. Discussion on ethics in writing, plagiarism, with exercises using, plagiarism checker online.

15 Hours

Essential Reading-

Thomas, C. G. (2021). Research Methodology and Scientific Writing. Germany: ANE Books Pvt. Limited. (chapter-5, 7 & 11)
Scientific Methods Used in Research and Writing. (2020). United Kingdom: CRC Press. (chapter- 1 & 4)

Unit II: Discussion on different formats for writing for scientific community, types of paper (short communication, original research article, review), various components (title, author affiliation, abstract, key words, introduction, material and methods, results and discussion, conclusion and bibliography). Writing and citation exercises for research grant, reports, Book review, write up mini profiles of prominent scientists, letters to the editor, opinion writing, interview with a scientist, career in scientific writing.

30 Hours

Essential Reading-

Thomas, C. G. (2021). Research Methodology and Scientific Writing. Germany: ANE Books Pvt. Limited. (chapter-5, 7 & 11)

Scientific Methods Used in Research and Writing. (2020). United Kingdom: CRC Press. (chapter- 1 & 4)

Recommended Reading-

Thomas, C. G. (2021). Research Methodology and Scientific Writing. Germany: ANE Books Pvt. Limited.

Scientific Methods Used in Research and Writing. (2020). United Kingdom: CRC Press.

Yadav, S.S., Gupta, S., Choudhary, A. K. (2025). Scientific Research Methodology: Principles, Tools, and Techniques. (n.p.): CRC Press.

Suggested Reading-

Dehesh, P. (2025). Scientific writing in a systematic review and Meta-Analyses. *Systematic Review and Meta-Analysis*, 195-208.

Zhang, Q., Ding, K., Lv, T., Wang, X., Yin, Q., Zhang, Y., ... & Chen, H. (2025). Scientific large language models: A survey on biological & chemical domains. *ACM Computing Surveys*, *57*(6), 1-38.

Amobonye, A., Lalung, J., Mheta, G., & Pillai, S. (2024). Writing a scientific review article: comprehensive insights for beginners. *The Scientific World Journal*, *2024*(1), 7822269.

GENERIC ELECTIVE COURSE – GE-3: BIOCHEMISTRY OF HUMAN DISEASES

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		
GE-3: Biochemistry of Human Diseases	**04**	**03**	**01**	**0**	**B.Sc. Biochemistry and Allied Subjects**	**-**

Number of hours: 45 (T) + 15 (T)

Learning Objectives:

This course aims to introduce students to the biochemical nature of various human diseases including genetic, metabolic, infectious diseases along with diseases due to protein folding. Students will learn to explore biochemical principles for understanding disease diagnosis, disease symptoms, progression and treatment. Clinical case studies will also be discussed to make students understand the role of biochemical processes in various diseases.

Learning Outcomes

On successful completion of this course, students will be able to:

1. Understand the biochemical basis of various human diseases
2. Explain the molecular mechanisms that lead to various diseases
3. Understand the biochemical mechanisms of diseases such as cancer, obesity, diabetes, neurodegenerative disorders and genetic disorders
4. Evaluate diagnostic and therapeutic measures for various biochemical and metabolic diseases

Course Contents

Unit I: Introduction of macromolecules (proteins, lipids, carbohydrates and nucleic acids) in human health and diseases, integrative metabolism and systems biology, Cellular energy and bioenergetics – ATP, redox functions, mitochondrial function in health and disease, nutrient sensing and energy balance, amino acid and nitrogen metabolism in context to monogenic disorders - inborn errors of metabolism; nucleotide metabolism- G6PD deficiency, Integration of metabolism and diseases; carbohydrate metabolism and diabetes; lipid metabolism and obesity; lipoproteins, their transport and cardiovascular disease

11 Hours

Essential Reading:

1. Molecular Biochemistry of Human Diseases By George Feuer, F. A. de la Iglesia (2021) CRC Press (volume I). (chapter 3-5).

Unit II: Case studies and key examples to learn how defects in key cellular functions and processes lead to diseases. cell cycle, signaling pathway defects and genetic basis of cancer, Protein misfolding diseases – Parkinson's, Alzheimer's and Huntington's disease, biochemical changes due to infection (by virus, bacteria and parasites).

13 Hours

Essential Reading:

1. Molecular Mechanisms of Neurodegenerative Diseases by Marie-Françoise Chesselet (2001) Springer. (chapter 4,5,6)
2. Protein Misfolding Diseases: Current and Emerging Principles and Therapies. Editor(s): Marina Ramirez-Alvarado, Jeffery W. Kelly, Christopher M. Dobson (2010), John Wiley & Sons, Inc. (chapter 12,13)

Unit III: genetic diseases – microdeletion/duplication syndromes, imprinting diseases, structural arrangements; cytogenetic disorders (aneuploidy); inherited metabolic disorders - lysosomal storage diseases, Neimann-Pick disease, Gaucher's disease, glycogen storage diseases; structural defects - Duchenne muscular dystrophy; cystic fibrosis and transport defects; sickle cell anemia, thalassemia; mitochondrial diseases

13 Hours

Essential Reading:

1. Human Genetic Diseases edited by Dijana Plaseska-Karanfilska (2011) IntechOpen. Chapter 1,6,8

Unit IV: Treatment and management of metabolic disorders, gene therapy, enzyme replacement therapy, hormone therapy, gene editing, bone marrow transplantation, stem cell- based therapies

8 Hours

Essential Reading:

1. Human Molecular Genetics, 4th Edition by Tom Strachan and Andrew Red (2011) by Garland Science, Taylor & Francis Group, LLC. Chapter 21

Tutorial: **15 Hours**

1. Clinical case studies taking examples of alterations in biochemical parameters for various diseases
2. Discussion on the role of identifying biochemical markers for diseases
3. Group discussions on novel innovations in treating genetic disorders (gene therapy/CRISPR)
4. Group discussions on discussing experimental approaches to study protein misfolding for neurodegenerative disorders

Suggested Reading:

Biochemistry by Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, Lubert Stryer · 2015. Macmillan Learning

Molecular Biochemistry of Human Diseases by George Feuer, F. A. de la Iglesia (2021) CRC Press (volume I).

Protein Misfolding Diseases: Current and Emerging Principles and Therapies Editor(s): Marina Ramirez-Alvarado, Jeffery W. Kelly, Christopher M. Dobson (2010), John Wiley & Sons, Inc.

Human Molecular Genetics, 4th Edition by Tom Strachan and Andrew Red (2011) by Garland Science, Taylor & Francis Group, LLC. Chapter 21

Human Genetic Diseases edited by Dijana Plaseska-Karanfilska (2011) IntechOpen.

GENERIC ELECTIVE COURSE – GE-4: BIOCHEMICAL TECHNIQUES 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		
GE-4: Biochemical Techniques and Applications	**04**	**03**	**01**	**0**	**B.Sc. Biochemistry and Allied Subjects**	**-**

Number of hours: 45 (T) + 15 (T)

Learning Objectives:

This course introduces students to basic biochemical techniques commonly used in teaching and research laboratories. It aims to provide hands-on knowledge of how biological molecules like proteins and DNA are studied, and how these techniques are applied in health, food, and environmental fields.

Learning Outcomes

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

1. Understand and prepare biological buffers and use simple lab instruments like pH meter and spectrophotometer.
2. Perform basic protein and DNA isolation and analysis using gel electrophoresis.
3. Explain the working of advanced tools like chromatography and enzyme assays.
4. Understand how biochemical techniques are used in disease testing, food safety, and forensic analysis.
5. Follow biosafety and ethical practices in laboratory work.

Course Contents

Unit I: Introduction to Biochemical Tools. Concepts of pH and buffers and their importance in biological systems; principles and applications of colorimetry and spectrophotometry; introduction to fluorescence spectroscopy; fundamentals of centrifugation – analytical and preparative types, including ultracentrifugation and density gradient methods; overview of chromatographic techniques – paper, column, and thin-layer chromatography (TLC).

12 Hours

Unit II: Protein and Nucleic Acid Analysis. Principles of electrophoresis and its applications in biomolecule separation – SDS-PAGE, native PAGE, agarose gel, and capillary electrophoresis; protein quantification methods (Bradford, Lowry); isolation and purification

of DNA and RNA; introduction to the polymerase chain reaction (PCR) and its applications; advanced chromatographic methods – gel filtration, ion-exchange, affinity chromatography

11 Hours

Unit III: Advanced Analytical Instruments. Principles and applications of high- performance liquid chromatography (HPLC) and affinity chromatography; overview of mass spectrometry and its role in biomolecule identification; use of light-based analytical techniques such as UV–visible, fluorescence, and atomic absorption spectroscopy; principles and applications of radioisotopic and stable isotope tracing in biological research with emphasis on quantification, detection, and radiation safety

11 Hours

Unit IV: Applications in Daily Life. Application of biochemical techniques in disease diagnostics (ELISA, glucose estimation), food quality testing, environmental monitoring, and forensic analysis; introduction to bioethics, data integrity, and laboratory safety in biochemical research.

11 Hours

Tutorials **15 Hours**

1. Discussion on experimental design in biochemistry and selection of appropriate analytical methods for different biological questions.
2. Interpretation of pH, buffer capacity, spectrophotometric data, electrophoretic profiles, and enzyme assay results.
3. Case-based discussion on chromatographic outputs and troubleshooting experimental challenges.
4. Applications of biochemical tools in research and diagnostics, including clinical testing, food safety, environmental monitoring, and ethical and safety considerations.

Suggested Readings

1. R.H. Garrett and C.M. Grisham (2017). Biochemistry, 6th Edition**.** Cengage Learning.
2. Keith Wilson and John Walker (2018). Principles and Techniques of Biochemistry and Molecular Biology, 8th Edition**.** Cambridge University Press.
3. J. Jayaraman (2011). Laboratory Manual in Biochemistry**.** New Age International Publishers.
4. David L. Nelson and Michael M. Cox (2023). Lehninger Principles of Biochemistry, 9th Edition**.** W.H. Freeman and Company.
5. R. Scopes (2013**).** Protein Purification: Principles and Practice, 3rd Edition**.** Springer-Verlag.