Sister Nivedita University

Post Graduate Course Structure for Biotechnology

According to UGC-CBCS

Course Structure for
M.Sc in Biotechnology

Department of Biotechnology
School of Health Science and Translational Research

M.Sc Biotechnology Course Structure

Category Definition and Credit Break Up

Semester	Credit					
	CC	DSE	GE	SEC	USC	Total/Sem
First	20	4	4	1	2	31
Second	20	4		1	2	27
Third	24			1	2	27
Fourth	12			1	2	15
Total Credit/Course	76	8	4	4	8	
					Total Credit	100

CC: Core Courses; **GE**: General Elective; **AECC:** Ability Enhancement Compulsory Course; **SEC**: Skill Enhancement Courses; **DSE**: Discipline Specific Elective; **USC:** University specified course

First Year

Category	Course name	Credit	Teaching Scheme		
			L	T	P
Semester I					
CC 1	Cell Biology and Cell Signalling	4	3	1	0
CC 2	Genetic Engineering	4	3	1	0
CC 3	Molecular Biology	4	3	1	0
CC 4	Fundamentals of Microbiology	4	3	1	0
CC 5	M.Sc Biotechnology Practical -I	4	0	0	8
DSE 1	Chemistry of Biomolecules	4	3	1	0
GE 1	Generic Elective	4	4	0	0
USC 1	Foreign Language I	2	2	0	0
SEC 1	Mentored Seminar I	1	1	0	0
Total Credit = 31			Teaching Hour = 35		
Semester II					
CC 6	Enzymes and Metabolism	4	3	1	0
CC 7	Cellular immune System	4	3	1	0
CC 8	Evolutionary Biology	4	3	1	0
CC 9	Fundamentals of Genetics	4	3	1	0
CC 10	M.Sc Biotechnology Practical -II	4	0	0	8
DSE 2	Biophysics	4	3	1	0
USC 2	Foreign Language II	2	2	0	0
SEC 2	Mentored Seminar II	1	1	0	0
Total Credit = 27			Teaching Hour = 31		

Second Year

Category	Course name	Credit	Teaching Scheme		
			L	T	P
Semester III					
CC 11	Fermentation and Bioprocess Technology	4	3	1	0
CC 12	Bioinformatics and Biostatistics	4	3	1	0
CC 13	Developmental Biology	4	3	1	0
CC 14	Pharmaceutical Science and Drug Delivery	4	3	1	0
CC 15	Advanced Biotechnology and Tissue Culture	4	3	1	0
CC 16	M.Sc Biotechnology Practical -III	4	0	0	8
USC 3	Foreign Language III	2	2	0	0
SEC 3	Mentored Seminar III	1	1	0	0
Total Credit = 27			Teaching Hour = 31		
Semester IV					
CC 17	Biotechnology Master Project/Dissertation	12	0	0	24
USC 4	Foreign Language IV	2	2	1	0
SEC 3	Biotechnology Master Seminar	1	1	0	0
Total Credit = 15			Teaching Hour = 27		

M.Sc. Biotechnology

Program Prerequisite: Students should have graduation degree in Biological and Allied Sciences with understanding of Physics and Chemistry in life governing processes.

Duration of Program: 4 Semesters (In 2 Years).

Program Educational Objectives: Competent in applying theoretical and practical hands on approach in Microbiology and Biotechnology. To apply the knowledge in providing solution to health, environmental and research problems. Promote Innovation and Research in cutting edge biotechnological research. To address the problems faced by India and to become a responsible citizen. Promote a strong sense of team spirit and brotherhood for building a strong India. Program Outcomes / Program Learning Outcome (Department Vision) The graduates of Microbiology or Biotechnology student must have: Ability to approach, analyze and bring out scientific solution for a given problem. Knowledge to implement multidisciplinary concepts and ideas for the development of innovative technologies. Expertise to demonstrate leadership, quality and entrepreneurship. Demonstrate technical skills in operation and maintenance of sophisticated instrumentations. ϖ Intelligence to protect their innovative research through IPR. Innovation for high quality research on par with international laboratories. Expert to explore scientific projects for need based industry. Capability to bring out good quality research proposal as well as research publications. Student would be competent discipline-specific studies, as well as to begin domain-related employment. To mould a responsible citizen who is aware of most basic domain-independent knowledge, including critical thinking and communication. The student graduating with the Degree of M.Sc. Microbiology/ Biotechnology should be able to acquire core competency, The student will enable to learn and demonstrate about basic experimental techniques in classical and modern biotechnology. The students will able to understand and explain various aspects such as Cell and Molecular Biology, Genetic Engineering, Immunology, Biochemistry and Enzymology. The students will gain sound knowledge in various fields including Plant, Animal, Microbial Biotechnology, Bioprocess technology, Medical Biotechnology and Environmental Biotechnology.

Analytical Ability: The students will capable of demonstrate the knowledge in understanding research and addressing practical problems. Application of various scientific methods to address different questions by formulating the hypothesis, data collection and critically analyse the data.

Critical thinking and Problem solving ability: An increased understanding of fundamental scientific concepts, principles and their applications is expected at the end of this course. Students will become critical thinker and acquire in depth knowledge in problem solving capabilities.

Digital knowledge: Students will acquire digital skills and integrate the fundamental concepts with modern biotechnological tools.

Ethical and Moral Strengthening: Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.

Team Work: Students will learn team workmanship in order to serve efficiently in institutions, industry and society.

Program Educational Objective

PEO 1: Professional Development: To develop the ability to acquire knowledge of Biology, Chemistry, Physics, Mathematics & Engineering in the students so that they may apply it professionally within the realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability with due ethical responsibility.

PEO 2: Core Proficiency: To provide the ability to identify, formulate, comprehend, analyse, design and solve biotechnological problems with hands-on experience in various technologies as well as using modern tools necessary for good laboratory practices to satisfy the needs of society and the industry.

PEO 3: Technical Accomplishments: To equip the students with the ability to design, simulate, experiment, analyse, optimise and interpret multidisciplinary concepts and contemporary learning so that they fit right into industrial set up.

PEO 4: Professionalism: To provide training, exposure and awareness on importance of soft skills for better career and holistic personality development as well as professional attitude towards ethical issues, team work, responsibility, accountability, multidisciplinary approach and capability to relate biotechnological issues to broader social context.

PEO 5: Learning Environment: To provide students with an academic environment and make them aware of excellence, develop the urge of discovery, creativity, inventiveness, leadership, written ethical codes and guidelines as well as the life-long learning to become a successful professional in the field of biotechnology.

Program Outcomes:

PO 1: Demonstrate knowledge of the basic concepts, principles and applications of biotechnology.

PO 2: Appreciate the complexity of biological systems, their interaction with each other as well as with the environment and the evolution of their adaptive mechanisms for sustenance.

PO 3: Develop scientific research aptitude and learn to formulate hypothesis, analyse and interpret results from a variety of relevant experiments, keeping sustainable development in mind.

PO 4: Learn good laboratory practices and understand laboratory safety issues and bioethical responsibilities while selecting and applying suitable scientific techniques and analytical tools in designing and conducting experiments.

PO 5: Demonstrate the ability to perform independent research as well as the capacity to be a leader/member of a collaborative and diverse enterprise.

PO 6: Develop effective written and oral communication skills necessary for disseminating the acquired knowledge of biology to diverse sections of the society.

PO 7: Recognize the relationship between science and society, and inculcate necessary scientific temper while pursuing a wide range of academic, research or industrial careers as well as entrepreneurship.

Program Specific Outcome

PSO 1: Carry out supervised transdisciplinary scientific studies and design independent research projects to tease out complex biological problems in the context of societal and ecological issues.

PSO 2: Fit right into industrial set up and learn new tools and technology with ease applying life-long learning relevant to professional and technical practice.

PSO 3: Function effectively in multi-disciplinary work environment with good interpersonal skills required to be a leader or as team member who is aware of professional ethics and societal responsibilities.

Program Specific Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
PSO 1	3	3	3	2	3	2	3
PSO 2	3	2	2	3	3	2	3
PSO 3	2	2	2	3	3	3	3
Average PSO	3	2	2	3	3	2	3

Semester – I
CC-1: Cell Biology and Cell Signaling
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1	Find how the cellular system works.
CO 2	Outline the basic concepts Of cell structure, function and signalling.
CO 3	Identify the structural and functional relations Of cell Organelles and their relation to cell signalling.
CO 4	Compare the interrelations Of the cell structure, functiOn with different cell signalling.
CO 5	Explain the integrated respOnses Of the cell structure, functiOn, signaling and the basic functiOning of theliving being.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	2	2	2	2	2
CO 2	3	2	2	2	2	2	2
CO 3	3	3	3	3	3	3	3
CO 4	2	3	3	2	3	2	3
CO 5	2	2	3	3	3	2	3
Average CO	3	2	3	2	3	2	3

Component: Theory

Unit 1: Foundations of Cell Biology (4 L)
Introduction to Cell Biology and historical milestones; Discovery of the cell and cell theory; Classification of living systems (Prokaryotic vs Eukaryotic cells); Methods for studying cells: light, fluorescence, confocal, electron microscopy, cell fractionation, flow cytometry; Introduction to cell culture techniques and applications.

Unit 2: Structure and Function of the Cell (8 L)
Types of cells and basic structural features; Plasma membrane: Fluid Mosaic Model, membrane lipids and proteins; Membrane transport: Passive (diffusion, osmosis, facilitated) and Active transport (pumps, carriers, channels, vesicles); Intracellular compartments: structure and function of different cell organelles; Cytoskeletal and motor proteins.

Unit 3: Cell Cycle, Chromatin, and Division (6 L)
Cell cycle phases and checkpoints; Mitosis and meiosis; Cyclins and CDKs; Chromosome structure and types; Nucleosome organization and role of histones; DNA packaging.

Unit 4: Cellular Communication and Membrane Dynamics (8 L)
Membrane trafficking: vesicular transport, receptor-mediated endocytosis, Cell adhesion molecules, integrins; Types of intercellular communication: direct (gap junctions), indirect (chemical messengers); Autocrine, paracrine, endocrine, and synaptic signalling mechanisms.

Unit 5: Signal Reception and Second Messenger Systems (8 L)
Overview of cell surface and intracellular receptors; Types of cell receptors: membrane-bound (ion-channel, GPCRs, RTKs) and cytoplasmic receptors (nuclear hormone receptors); Second messengers: cAMP, cGMP, IP3, DAG, Ca^{2+}; Signal amplification and integration

Unit 6: Key Signalling Pathways in Eukaryotes (8 L)
MAPK/ERK pathway; JAK-STAT pathway; PI3K-AKT-mTOR pathway; IP3-DAG pathway; Regulation and cross-talk among signalling pathways; Chemotaxis and quorum sensing in bacteria.

Unit 7: Cancer and Programmed Cell Death (6 L)
Apoptosis: intrinsic and extrinsic pathways, perforin-granzyme pathways, Caspase activation and apoptotic signalling; Necrosis and autophagy; Cancer Biology: oncogenes, tumor suppressors, hallmarks of cancer; Cell signalling in tumor progression; Therapeutic targeting of signalling pathways.

Suggested Books:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2022). Molecular Biology of the Cell (7th ed.). Garland Science.
2. Cooper, G.M., & Hausman, R.E. (2021). The Cell: A Molecular Approach (8th ed.). Oxford University Press.
3. Alberts, B., Bray, D., Hopkin, K., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2019). Essential Cell Biology (5th ed.). W.W. Norton & Company.
4. Lim, W.A., Mayer, B.J., & Pawson, T. (2014). Cell Signaling (1st ed.). Garland Science.
5. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Scott, M.P. (2021). Molecular Cell Biology (9th ed.). W.H. Freeman and Company.
6. Gomperts, B.D., Kramer, I.M., & Tatham, P.E.R. (2016). Signal Transduction (2nd ed.). Academic Press.

CC-2: Genetic Engineering
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1	The course leads to the understanding of procedures that have been developed to exploit Our knowledge Of the replication and expression of genetic information.
CO 2	The paper helps the students to understand the processes involved to identify, isolate, amplify, analyse and express virtually any cellular material, whether it is DNA or RNA or Protein.
CO 3	Students will understand the basics Of gene cloning, the role of enzymes and vectors for genetic engineering, and gene transfer methods.
CO 4	Acquiring theoretical knowledge in the techniques, tools, application and safety measures Of genetic engineering.
CO 5	Describes genome mapping and sequencing and methods for gene therapy.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	3	3	3	2	3
CO 2	3	2	3	3	3	2	3
CO 3	3	2	3	3	3	2	3
CO 4	3	2	3	3	3	2	3
CO 5	3	2	3	3	3	2	3
Average CO	3	2	3	3	3	2	3

Component: Theory

Unit 1: Enzymatic Tools and Techniques [8 L]
Tools for genetic engineering: general requirements for performing a genetic engineering experiment; Restriction digestion, enzymes: restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; Ligation: cohesive and blunt end ligation; linkers; adaptors; homo polymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes

Unit 2: Vectors [10 L]
Plasmids; Bacteriophages; M13 vectors; PUC19 and Bluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome, YACs, BACs. Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors. Protein purification: His-tag; GST-tag; MBP-tag etc. Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri plasmids as vectors, yeast vectors, shuttle vectors.

Unit 3: PCR Technologies, Sequencing, and Mutation Detection [8 L]
PCR and primer design; fidelity of thermostable enzymes; DNA polymerases; Types of PCR Cloning of PCR products; TA cloning vectors; proof reading enzymes; PCR based site specific

mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP, RAPD, AFLP, DNA microsatellite, DNA marker, Polymorphism

Unit 4: Advanced Cloning Strategies and Hybridization Techniques [6 L]
Methods used in cloning: Positional cloning, functional cloning, therapeutic cloning, Gateway cloning, Gibson cloning; hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.

Unit 5: Molecular Interaction Studies and Functional Genomics Tools [8 L]
Interaction studies: cDNA analysis, Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNaseI footprinting, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Unit 6: Gene Silencing, Transgenics, and Genome Editing Technologies [8 L]
Gene silencing techniques; Transposon and jumping gene, introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems e.g. fruit flies (Drosophila), worms (*C. elegans*), frogs (Xenopus), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS.

Suggested Books

1. Gupta, P.K. (2020). Molecular Biology and Genetic Engineering (Revised ed.). Rastogi Publications.
2. Green, M.R., & Sambrook, J. (2012). Molecular Cloning: A Laboratory Manual (4th ed.). Cold Spring Harbor Laboratory Press.
3. Primrose, S.B., & Twyman, R. (2006). Principles of Gene Manipulation and Genomics (7th ed.). Wiley-Blackwell.
4. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R. (2013). Molecular Biology of the Gene (7th ed.). Pearson Education.
5. Brown, T.A. (2016). Gene Cloning and DNA Analysis: An Introduction (7th ed.). Wiley-Blackwell.

CC-3: Molecular Biology
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1	Understand the structure and organization of DNA and RNA across organisms.
CO 2	Explain the mechanisms of DNA replication, transcription, and translation.
CO 3	Identify types of DNA damage and describe major DNA repair pathways.
CO 4	Describe RNA processing events and RNA-based gene regulation.
CO 5	Summarize the genetic code, translation machinery, and post-translational modifications.
CO 6	Understand the role of epigenetic modifications in gene regulation and disease.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	3	2	3	3	3
CO 2	3	3	3	2	3	3	3
CO 3	3	3	3	2	3	3	3
CO 4	3	3	3	2	3	3	3
CO 5	3	3	3	2	3	3	3
CO 6	3	3	3	2	3	3	3
Average CO	3	3	3	2	3	3	3

Component: Theory

Unit 1: Molecular Architecture of Genetic Material [4 L]
Historical development of DNA structure from Miescher to Watson–Crick. Structural forms of DNA (A-, B-, Z-DNA), salient features of the double helix. Denaturation, renaturation, and Cot curve analysis. DNA topology: supercoiling, linking number, role of topoisomerases. Organization of DNA in prokaryotes, eukaryotes, viruses. Structure and functions of RNA species, mitochondrial and chloroplast genomes, siRNA, and miRNA.

Unit 2: DNA Replication in Prokaryotes and Eukaryotes [10 L]
Mechanisms of bidirectional and unidirectional replication. Semi-conservative and semi-discontinuous models. Enzymes involved: DNA polymerases, primase, ligase, helicase, telomerase and others. Comparative replication models and replication fork dynamics. Regulation of replication initiation and elongation.

Unit 3: DNA Damage and Repair Mechanisms [6 L]
Types and causes of mutations, Ames test, mutant isolation. DNA repair pathways: base excision repair, nucleotide excision repair, mismatch repair. Role of recombination and trans lesion synthesis in maintaining genomic integrity.

Unit 4: Transcriptional Processes in Prokaryotes and Eukaryotes [6 L]

Basics of transcription and its regulation. Prokaryotic transcription: RNA polymerase, promoter structure. Eukaryotic transcription: RNA polymerases I, II, III; general transcription factors and promoter elements. Chromatin's role in transcriptional control.

Unit 5: Post-Transcriptional Processing and RNA Regulation [6 L]

Introns, exons, RNA splicing and spliceosome machinery. Alternative splicing, mRNA capping, polyadenylation. Processing of rRNA and tRNA. RNA interference: roles of siRNA and miRNA in gene regulation.

Unit 6: Genetic Code and Protein Translation [6 L]

Genetic code properties, codon bias, wobble hypothesis. Translation components and mechanism in prokaryotes and eukaryotes: initiation, elongation, termination. Fidelity and inhibitors of translation.

Unit 7: Post-Translational Events and Protein Maturation [6 L]

Post-translational modifications: phosphorylation, glycosylation, ubiquitination. Protein folding, molecular chaperones, targeting and transport. Protein degradation pathways: ubiquitin-proteasome system and autophagy.

Unit 8: Epigenetic Regulation [4 L]

DNA methylation, histone modifications, non-coding RNAs. Epigenetic effects on transcription and translation. Role in development and disease.

Suggested Books:

1. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., & Losick, R. (2013). Molecular Biology of the Gene (7th ed.). Pearson Education.
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Scott, M.P. (2021). Molecular Cell Biology (9th ed.). W.H. Freeman and Company.
3. Krebs, J.E., Goldstein, E.S., & Kilpatrick, S.T. (2017). Lewin's Genes XII (12th ed.). Jones & Bartlett Learning.
4. Snustad, D.P., & Simmons, M.J. (2015). Principles of Genetics (7th ed.). Wiley.
5. Weaver, R.F. (2011). Molecular Biology (5th ed.). McGraw-Hill Education.

CC-4: Fundamentals of Microbiology
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcome:

CO 1	Understand better the various aspects of prokaryotic cell structure, growth and nutrition.
CO 2	Comprehend the structure, classification and cultivation of viruses.
CO 3	Describe the various advanced microscopic methods used to observe prokaryotes.
CO 4	Develop a strong understanding about the physical and chemical control of microbes.
CO 5	Develop a conceptual idea about the mechanisms of drug resistance.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	3	1	1	2	2
CO 2	3	3	3	2	1	2	2
CO 3	3	3	3	2	1	2	2
CO 4	3	3	3	2	1	2	2
CO 5	3	3	3	1	1	2	2
Average CO	3	3	3	2	1	2	2

Component: Theory

Unit 1: Bacterial cell structure: cellular organization. Size shape and arrangements of bacterial cells. Cell wall, flagella cilia, ribosomes and other cellular parts. **[4L]**

Unit 2: Microbial Growth: Nutritional requirements of bacteria. Culture media. Different types of media, Pure culture techniques. Different stages of bacteria growth curve. Measurement of microbial growth. Effect of different parameters on microbial growth. **[4L]**

Unit 3: Control of microbial growth: concept of sterilization. Action of microbial control agents. Different modes of sterilization, physical methods: UV radiation, dry heat, moist heat, incineration, chemical methods: use of different chemicals as microbial control agent. Antibiotics: classification and mode of action. **[6L]**

Unit 4: Microbial Staining: Concept of microscope, mode of staining, dye and stain, acidic dyes and basic dyes. Different staining techniques: negative stain, endospore stain, flagella stain. Staining for electron microscope. **[4L]**

Unit 5: Microbial diversity: Microbial evolution, metabolic diversity of bacteria, Proteobacteria and its different classes. Archaeabacteria and extremophiles. **[4L]**

Unit 6: Microbial ecology: Water microbiology, microbes in water bodies, fresh water and contaminated water, potable water. Air microbiology: microbes in air, Soil Microbiology: rhizosphere and its microbial population, biogeological cycles: carbon cycle, nitrogen cycle, sulfur cycle and phosphorus cycle. **[6L]**

Unit 7: Virology: Classification of virus, structures of different types of viruses, Virological techniques, Bacteriophage. Life cycles of bacteriophages – lytic and lysogenic. Viral genetics, molecular mechanism of lambda genome.

[10L]

Unit 8: Eukaryotic microbiology: cellular organization of eukaryotic microbes. Protists: classification and morphology, Fungi: classification and morphology, Algae: red algae, green algae, cyanobacteria. **[6L]**

Unit 9: Microbial diseases: diseases caused by bacteria, virus, amoeba, fungi and algae, Prions, symptoms and cure. **[4L]**

Suggested Books

1. Madigan, M.T., Bender, K.S., Buckley, D.H., Sattley, W.M., & Stahl, D.A. (2021). Brock Biology of Microorganisms (16th ed.). Pearson Education.
2. Tortora, G.J., Funke, B.R., & Case, C.L. (2018). Microbiology: An Introduction (13th ed.). Pearson Education.
3. Willey, J.M., Sandman, K., & Wood, D. (2020). Prescott's Microbiology (11th ed.). McGraw-Hill Education.
4. Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. (2001). Microbiology (5th ed.). McGraw-Hill Education.
5. Flint, S.J., Racaniello, V.R., Rall, G.F., Skalka, A.M., & Enquist, L.W. (2020). Principles of Virology (5th ed.). ASM Press.
6. Dimmock, N.J., Easton, A.J., & Leppard, K.N. (2016). Introduction to Modern Virology (7th ed.). Wiley-Blackwell.
7. Alexopoulos, C.J., Mims, C.W., & Blackwell, M. (1996). Introductory Mycology (4th ed.). Wiley.

CC-5: MSc. Biotechnology Practical-I
Credit: 4 (L0 T0 P8)

Course Outcomes:

CO 1	Develop skills in molecular biology techniques such as DNA isolation, PCR amplification, and gene cloning.
CO 2	Gain expertise in microbiological and biochemical laboratory techniques, including protein isolation, SDS-PAGE, and staining methods
CO 3	Design and conduct experiments involving recombinant DNA technology, including plasmid transformation and cloning into vectors
CO 4	Perform advanced microscopy techniques, including Barr body isolation and the study of mitosis and meiosis in plant tissues.
CO 5	Master techniques for nucleic acid and protein quantification, using methods like real-time PCR and protein electrophoresis.
CO 6	Analyze and interpret experimental data for microbiological, molecular, and biochemical applications, fostering problem-solving and critical thinking skills in lab settings.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	3	3	3	2	3
CO 2	3	3	3	3	3	2	3
CO 3	3	3	3	3	3	2	3
CO 4	3	3	3	3	3	2	3
CO 5	3	3	3	3	3	2	3
CO 6	3	3	3	3	3	2	3
Average CO	3	3	3	3	3	2	3

Component: Practical
List of Experiments

1. Isolation of total genomic DNA from plant tissue.
2. Isolation of plasmid DNA from bacterial samples using alkaline lysis method.
3. Primer designing.
4. PCR amplification of a candidate gene from the isolated genomic DNA and analysis of the PCR product by agarose gel electrophoresis.
5. Cloning of the PCR amplified product in pGEM-T Easy vector.
4. Preparation of E. Coli (DH5 α) competent cells and transformation of plasmid DNA
5. Screening of recombinant clones by blue white screening.
6. Isolation and quantification of protein followed by SDS-PAGE.
7. Demonstration of real-time PCR.
8. Preparation of onion root tip for mitosis and meiosis.
9. Barr body isolation and observation under light microscope.
10. Plaque Assay using agar overlay method.
11. Fungal Staining.
12. Acid-Fast Staining.

DSE-1: Chemistry of Biomolecules
Credit – 4 (4L-0T-0P); Lecture: 48 L

Course Outcomes:

CO 1	Understand the significance of biochemistry (bonding, pH, molarity, normality) in the biological system.
CO 2	Understand the chemistry of water, diffusion Osmotic pressure and importance of aqueous medium in thebiological reactions.
CO 3	Describe the chemistry, bonding, thermodynamic stability behind the structures of carbohydrates, lipids,proteins and nucleic acids.
CO 4	Describe the different structural organization of proteins required for their function.
CO 5	Factors affecting protein structures, protein folding and degradation.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	3	1	3	3	3
CO 2	3	3	3	1	3	3	3
CO 3	3	3	3	1	3	3	3
CO 4	3	3	3	1	3	3	3
CO 5	3	3	3	1	3	3	3
Average CO	3	3	3	1	3	3	3

Component: Theory

Unit 1: Foundation of Biochemistry: [8L]

Concepts of molecular structure: atoms and molecules, atomic theory, structure of O, N and H atoms. Atomic structure of Carbon and concept of stereochemistry. Forces in molecules and formation of bonds, types of bonds and interactions. Molecular interactions. Structure and properties of water molecule. Few Landmark experiments like: Miller-Urey Experiment, Hershey-Chase Experiment, Griffith's Experiment and Avery-MacLeod-McCarty Experiment.

Unit 2: Carbohydrates and Glycobiology: [10L]

Concept of carbohydrate and sugar, Structural classification of carbohydrates: Monosaccharides, Disaccharides, Oligosaccharides and Polysaccharides. Fischer projection formulas. Haworth perspective formulas: Hemiacetal and Hemiketal formation, Furan and Pyran structure. Concept of Mutarotaion, Stereoisomerization: Anomer, Epimer, Enantiomers and Diastereomers. Uronic acid formation. Reducing and nonreducing sugars. Formation and types of Glycosidic bonds. Structures of Disaccharides: Maltose, Lactose, Sucrose and Trehalose. Homopolysaccharides and heteropolysaccharides, Starch and glycogen. Chitin and dextran. Glycoconjugates: Proteoglycans, Glycoproteins,and Glycolipids. The Sugar Code. Principle of chemical estimation of sugar.

Unit 3: Amino Acids and Proteins: [10L]

Structure and classification of Amino acid residues, Essential and non essential amino acids. Titration of Amino Acids: Amphoteric molecule, Zwitterion, pK values; Isoelectric point. Detection of amino acids: Ninhydrin test. Peptide bond formation and polypeptide. Prosthetic group. Different levels of Protein structure: Primary, Secondary, Tertiary and Quaternary. Polypeptide sequencing: Edman degradation. Three dimensional structure of protein: Conformation of protein. Ramachandran Plot. Multimeric nature of protein. Motifs and domains. Protein folding. Molecular chaperones. Rotational symmetry: cyclic symmetry, dihedral symmetry and icosahedral symmetry. Protein denaturation. Function of proteins (Channel proteins, antibody, enzymes etc.)

Unit 4: Lipids: [10L]

Fatty acids: Structure, nomenclatures and classification. Isomerization in fatty acids. Glycerol and lipid formation. simple, complex, derived lipids. Phospholipids and glycolipids. Plasmalogens and platelet-activating factor. Sphingolipids. Sterols. Lipids as Signals, Cofactors, and Pigments. Prostaglandins, Thromboxanes and Leukotrienes. Properties of lipids: Saponification, Acetyltion, Iodine number, volatile fatty acid number.

Unit 5: Nucleic acid: [10L]

Components of DNA and RNA molecules. Discovery of DNA double helix. Structure of DNA double helix and RNA. Hoogsteen pairing. Fragility of DNA and RNA molecules. Types of DNA structures (A-DNA, B-DNA & Z-DNA). Denaturation of DNA double helix: Cot curve and Tm, Hyperchromic shift. Different RNA molecules (t-RNA, m-RNA and r-RNA). Modifications in Nucleotides. Mitochondrial and Chloroplast DNA. Detection of DNA/RNA.

Suggested Books

1. Nelson, D.L., & Cox, M.M. (Lehninger) (2021). Principles of Biochemistry (8th ed.). W.H. Freeman.
2. Rafi, M.D. (2019). Textbook of Biochemistry (Rev. ed.). University Press.
3. Stryer, L. (2019). Biochemistry (8th ed.). W.H. Freeman & Co.
4. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W., & Weil, P.A. (2018). Harper, Illustrated Biochemistry (31st ed.). McGraw-Hill Education.
5. Voet, D., & Voet, J.G. (2016). Biochemistry (5th ed.). Wiley

Semester – II
CC – 6: Enzymes and Metabolism
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1: Comprehend the concept of bioenergetics and thermodynamic principles in biology.

CO 2: Understand and evaluating free energy and redox potential in relation to metabolism.

CO 3: Describe the mechanism of enzyme action and different classes of enzymes and factors affecting their function.

CO 4: Understand how enzymes and cofactors function in bioenergetics reactions.

CO 5: Understand the mechanisms and regulation of anabolic and catabolic processes of macromolecules like carbohydrates, protein, lipid and nucleic acids.

CO 6: Describe the central role of ATP.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	2	-	2	2	3
CO 2	3	3	2	-	2	2	3
CO 3	3	3	2	-	2	2	3
CO 4	3	3	2	-	2	2	3
CO 5	3	3	2	-	2	2	3
CO 6	3	3	2	-	2	2	3
Average CO	3	3	2	-	2	2	3

Component: Theory

Unit 1: Thermodynamics and Bioenergetics: Laws of thermodynamics, concept of free energy, entropy and enthalpy. Standard free energy and equilibrium constant. **[4 L]**

Unit 2: Introduction to enzymes: proteins as enzymes, enzymatic activity, enzyme substrate complex, transition state, activation energy, rate constant, binding energy, catalysis of biochemical reactions. Enzyme kinetics, Km and V max, Michaelis – Menten equation. Enzyme inhibition, types of enzyme inhibition. **[8 L]**

Unit 3: Metabolism of sugar molecules: Glycolysis and its control, Fates of pyruvate under aerobic and anaerobic condition. Feeder pathways of glycolysis, Pentose phosphate pathway. Reactions of Citric acid cycle, production of NADH and $FADH_2$. Glyoxylate cycle, structure of mitochondria, electron transfer reaction and electron transport chain, regulation of electron transport chain, oxidative phosphorylation and ATP synthesis. Gluconeogenesis, biosynthesis of starch and glycogen. **[10L]**

Unit 4: Oxidation of fatty acids: activation of fatty acids and transportation to mitochondria, beta oxidation, oxidation of unsaturated fatty acids, oxidation of odd chain fatty acids, alpha oxidation, omega oxidation, ATP generation calculation. **[6L]**

Unit 5: Amino acid oxidation: Urea cycle, link between citric acid cycle and urea cycle, Pathways of amino acid degradation, conversion of amino acid to acetyl CoA. Conversion of amino acids to alpha keto glutarate. Conversion of amino acids to succinyl CoA. **[6L]**

Unit 6: Nucleic acid Metabolism: synthesis of nucleotides, salvage and de-novo pathways. **[2L]**

Unit 7: Photosynthesis: Site of photosynthesis, basic structure of chlorophyll, absorption and action spectra, role of PSI and PSII, Light reaction, chemiosmosis hypothesis, photophosphorylation, Dark reaction, CO 2 fixation, role of RUBISCO, C3 and C4 cycle, 'Kranz' anatomy, CAM pathway, photophosphorylation, bacterial photosynthesis (structure of Bacteriochlorophyll, non-cyclic and cyclic photosynthesis, anoxygenic photosynthesis, Rhodopsin-based phototrophy). **[4L]**

Text/ Reference Book

1. Principles of Biochemistry., A Lehninger.
2. Textbook of Biochemistry., MD Rafi
3. Biochemistry., L Stryer.
4. Harper's Biochemistry., R. K. Murray
5. Biochemistry., Voet and Voet

CC-7: Cellular Immunology
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcome:

CO 1: Learn the key concepts of immunological mechanisms in detail and how this could be extrapolated towardsdevelopment of novel therapeutic interventions against various diseases

CO 2: Explain different the antigen-antibody interaction based diagnostic test, their sensitivity & specificity andalso suggest tests for successful diagenesis of ongoing disease in the community.

CO 3: Will be able to comprehend the genetic organization of the genes meant for expression of immune cellreceptors and the bases of the generation of their diversity

CO 4: Gain knowledge about the vaccines available for different diseases and their method of preparation, Con-ventional vaccine vs recombinant vaccine, DNA & RMA vaccines

CO 5: Learn the production of chimeric and monoclonal Antibodies production using Hybridoma technology andtheir applications

CO 6 Understand and explain the problems associated with the vaccine development for the infectious diseasesfor which vaccines are yet to be developed.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	3	3	2	-	2
CO 2	2	3	3	2	-	-	3
CO 3	2	3	3	3	-	-	3
CO 4	3	-	3	3	3	-	3
CO 5	2	2	3	3	-	-	3
CO 6	3	3	3	3	-	-	3
Average CO	3	3	3	3	-	-	3

Component: Theory

Unit 1: Immunology-fundamental concepts: Components of innate and acquired immunology, complement and inflammatory responses, haematopoiesis, organs and cells of the immune system-primary and secondary lymphoid organs, lymphatic systems (MALT & GALT), Major Histocompatibility complex (MHC)- MHC genes, antigen processing and presentation, HLA typing. **[4L]**

Unit 2: Antigen: structure and properties of antigen, antigenicity vs immunogenicity, concepts of epitopes, properties of B cell and T cell epitopes, Antigenic determinants. **[4L]**

Unit 3: Immune responses: Immunoglobulins- Basic structure, classes and subclasses, antigenic determinants, action of antibody, kinetics of immune response, B-cell receptor, B-cell maturation, activation and differentiation, MHC/ HLA; antigen processing and presentation; T-cells, T-cell receptors, T-cell maturation, activation and differentiation, Cell-mediated immune responses, ADCC auto immunity, Cell-cell co-operation, Hapten-carrier system immune-deficiency diseases,

monoclonal and polyclonal antibodies, clonal selection theory. Complement activation. **[8L]**

Unit 4: Antigen - Antibody interactions: Precipitation reactions- precipitation reaction in fluids and in gel, radial immunodiffusion (Mancini method), double diffusion (Ouchterlony method), Agglutination- Prozone effect, direct agglutination and passive agglutination. **[8L]**

Unit 5: Immunization: Active and passive immunization; Live, killed, attenuated, subunit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein-based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines; Catalytic antibodies and generation of immunoglobulin gene libraries. Adenovirus Vaccine, mRNA vaccine. **[6L]**

Unit 6: Genetic-Immuno-regulations: Introduction to tumour immunology, autoimmune disorders. Use of transgenic animals in immunology, experimental immunology, vaccine, development, stem cell technology, Immunodiagnostics. **[6L]**

Unit 7: Hypersensitivity: Types of hypersensitivity - immediate and delayed hypersensitivity, autoimmune diseases, transplantation and immunity, immunity to infectious agents. Vaccines and Vaccination, types of vaccines including new generation vaccines. Tumor immunology. **[6 L]**

Unit 8: Advanced immunological techniques: ELISA, RIA, Western Blot, Flow cytometry, Immunoblot and Immuno fluorescent techniques, FACS, Detection of antigens in living cells (Stem Cell Markers), in situ localization by techniques such as FISH and GISH, Hybridoma technology - production and applications of monoclonal antibodies. **[6 L]**

CC-8: Evolutionary Biology
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1: The knowledge about the origin of life forms, its time scale, evidences in form of fossils and understanding about why evolution is a true phenomenon.

CO 2: The knowledge about the theoretical framework of evolutionary biology, especially elementary concepts of natural selection, Mendellian genetics and population genetics.

CO 3: In-depth understanding about the two major evolutionary outcomes i.e., adaptation and speciation.

CO 4: The students will also learn about animal behaviour and its role in adaptation and speciation.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	3	1	1	1	3
CO 2	3	3	3	1	1	1	3
CO 3	3	3	3	1	1	1	3
CO 4	3	3	3	1	1	1	3
Average CO	3	3	3	1	1	1	3

Component: Theory

Unit 1: Origins of earliest life and history of evolutionary ideas: Biochemical origin of life and nature of early life forms - Oparin and Haldane; Experiment of Miller (1953), evolution of prokaryotes and eukaryotes. Pre-Darwinian concepts and theories including Lamarckism, Darwinian theory, neo-Darwinian synthesis, Anti-evolutionary ideas of creationism and their scientific rebuttal. **[8L]**

Unit 2: Evidence in favour of evolution and sources of variations: Geological time scale, fossil records: types of fossils. Adaptive radiations and distribution of species. Genes as the units of heredity and contributions of Mendel's experiments. Sources of heritable variations. Domains of evolutionary biology: patterns and processes. **[8L]**

Unit 3: Adaptation: Concept of populations and calculation of allele frequencies in a population: Hardy-Weinberg law and equilibrium. Evolutionary forces disrupting H-W equilibrium. Natural selection: definition, concept of fitness, selection coefficient, Types of natural selection with examples- disrupting, stabilizing, directional. Genetic drift, basic concepts of founder's effect, bottleneck phenomenon. Sexual selection, sexual conflict and coevolution. **[12L]**

Unit 4: Speciation and Extinction: Species concepts and modes of speciation, isolating mechanisms and hybridisation. Convergent evolution and inter-population variations: clines, races. Concepts of neutral evolution, molecular divergence and molecular clocks, Phylogenetic tools, classification and identification. Major mass extinctions in the history of life and their impacts on biodiversity on earth. **[10L]**

Unit 5: Behavioural Ecology: Innate and learned behaviour. social behaviour – communication, dominance, territoriality, mating systems, parental investment, biological rhythm, Methods of studying behaviours: ad libitum observations, focal animal sampling, scan animal sampling, etc. Habitat selection and optimality in foraging, migration, orientation and navigation, domestication and behavioral changes. **[10L]**

CC-9: Fundamentals of Genetics
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1: Understand and explain the basic concert of gene.
CO 2: Understanding the pre Mendelian genetic concepts.
CO 3: Study the laws and concepts of Mendelian inheritance and principles of deviation from Mendelian inheri- tance with examples.
CO 4: Understand concepts of multiple alleles with examples.
CO 5: Understand the mechanism of sex determination in different organisms.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	-	2	3	-	2	-	3
CO 2	-	2	3	-	2	-	3
CO 3	-	2	3	-	2	-	3
CO 4	-	2	3	-	2	-	3
CO 5	-	2	3	-	2	-	3
Average CO	-	2	3	-	2	-	3

Component: Theory

Module 1:

Unit 1: Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests. **[2L]**

Unit 2: Mendelian principles: Laws of mendelian genetics, determination of genetics combinations in generation (cross hybrid tests), Dominance, segregation, independent assortment. Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters. **[4L]**

Unit 3: Population genetics: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis. Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications. Recombination: Homologous and non-homologous recombination including transposition. **[6L]**

Unit 4: Quantitative Genetics: Polygenic inheritance, heritability and its measurements, QTL mapping. **[6L]**

Unit 5: Human Genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders. **[6L]**

Module 2:

Unit 1: Extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes,

maternal inheritance. Evidence for Cytoplasmic factors, cytoplasmic inheritance, extra-nuclear inheritance (mitochondrial, chloroplast), Kappa articles in Paramoecium, Sigma factor in Drosophila, Cytoplamic. Male Sterility (CMS) in maize maternal inheritance, uniparental inheritance, non-chromosomal inheritance. **[8L]**

Unit 2: Methods of genetic transfers: transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes. **[6L]**

Unit 3: Operon: concept of operon, *Lac* operon: structure and regulation, *Trp* operon, *Ara* operon. **[10L]**

CC-10: MSc. Biotechnology Practical-II
Credit: 4 (L0 T0 P8)

Course Outcomes:

CO 1 Acquire skills to carry out molecular biology and rDNA technology experiments using analytical tech- niques.

CO 2 Gain understanding and acquire skills on techniques associated with proteomics.

CO 3 Understand the state the principles and perform the routine Immunology procedures performed in the clinical laboratories.

CO 4 Evaluate laboratory test outcomes and determine the validity of the test results obtained for blood grouping, Widal Test, etc.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	3	2	2	3	2
CO 2	3	3	3	3	2	3	2
CO 3	2	2	3	3	3	2	3
CO 4	2	2	3	3	3	2	3
Average CO	3	3	3	3	3	3	3

Component: Practical

List of Experiments

1. Study of fossils- Horses and birds.
2. Verification of Hardy-Weinberg equilibrium in a population by chi square analysis.
3. Chemical cell disruption and extraction of intracellular products
4. Gel analysis/ assay for dialysed product
5. Chromatography
6. Karyotyping and gene analysis
7. Tetrad analysis
8. Ouchterlony double diffusion
9. ELISA and RIA.

DSE-2: Biophysics
Subject Code: 2110021102
Credit – 4 (4L-0T-0P); Lecture: 48 L

Course Outcomes:

CO 1 Illustrate the basic principle and techniques to understand the biological problem.

CO 2 Identify the physical principles responsible for maintaining the basic cellular function.

CO 3 Understand the applications of biophysics and principle involved in bio instruments.

CO 4 Describe the methodology involved in bio-techniques.

CO 5 Describe the applications of bio instruments.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	3	3	3	2	3
CO 2	3	2	3	3	3	2	3
CO 3	3	1	3	3	3	2	3
CO 4	3	1	2	3	3	2	3
CO 5	3	1	3	3	3	2	3
Average CO	3	1	3	3	3	2	3

Component: Theory
Purpose: This course aims to help the students to gain an advanced level of understanding in the comprehensive components of analytical and instrumentation techniques used in life

Unit 1: Colligative property: [6 L]
Overall concept of Surface tension, Viscosity, Measurement of pH, Radioactive labelling& counting, Autoradiograph.

Unit 2: Microscopy: [12L]
Introduction to optics, principles of image formation, light microscopy techniques, principles of fluorescence, digital imaging, confocal microscopy, TIRF, STORM/PALM, STED, FRET-FLIM, and FRAP techniques, structured illumination, two-photon fluorescence, second harmonic generation, vibrational imaging, scanning probe microscopy (SPM) techniques, atomic force microscopy (AFM), electron microscopy (SEM, TEM and STEM), and X-ray microscopy/microCT., Application of spectroscopy in various biological fields.

Unit 3: X-Ray Crystallography: [4 L]
X-ray diffraction, Bragg equation, Reciprocal lattice, Miller indices & Unit cell, Concept of different crystal structure, Application of crystallization.

Unit 4: Spectroscopy: [12 L]
Concept of Stoke's shift and Jablonski diagram. UV-Visible spectroscopy: working principle, Instrumentation, and applications, IR spectroscopy: working principle, Instrumentation, and applications, ESR spectroscopy : working principle and applications, NMR Spectroscopy– Basic principle of NMR spectroscopy, Experimental technique & instrumentation, Chemical shift,

Hyperfine splitting, Relaxation process. Absorption Spectroscopy– Simple theory of the absorption of light by molecules, Beer-Lambert law, Instrumentation for measuring the absorbance of visible light, Factors affecting the absorption properties of a Chromophore. Flowcytometry.

Unit 5: Separation & Identification of Materials-Concept of Chromatography (Partition Chromatography, Paper Chromatography, Adsorption Chromatography, TLC, GLC, Ion Exchange Chromatography, Gel Chromatography, HPLC, Affinity Chromatography); Electrophoresis (Gel Electrophoresis, Paper Electrophoresis) [8L]

Texts/References

1. Upadhyay and Upadhyay, Biophysical chemistry-Principle and techniques.
2. Gale Rhodes, Crystallography made crystal clear.

Semester - III
CC-11: Fermentation and Bioprocess Technology
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1	Demonstrate an understanding of the historical development, industrial relevance, and components of integrated bioprocess systems, including upstream and downstream operations.
CO 2	Explain the principles of fermentation processes, types of bioreactors, and control of key operational parameters in microbial cultivation and product formation.
CO 3	Apply stoichiometric and kinetic models to analyze microbial growth, product formation, and energy utilization in bioprocesses.
CO 4	Design and evaluate fermentation media and sterilization strategies with respect to microbial requirements and industrial-scale operations.
CO 5	Integrate downstream processing techniques for efficient product recovery, purification, and finishing, with a focus on regulatory compliance, quality control, and process validation.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	1	3	1	2	3	2	3
CO 2	3	3	3	2	3	1	2
CO 3	2	3	1	3	3	3	3
CO 4	1	2	1	2	1	2	3
CO 5	2	2	1	2	2	2	3
Average CO	2	3	2	2	3	2	3

Component: Theory

Unit 1: Introduction to Bioprocess Technology [6L]
Historical development of bioprocess technologies, role of bioprocess engineer in the biotechnology industry, concept of Bioprocess, outline of an integrated bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses, generalized process flow sheets. A brief survey of organisms, processes, products and market economics relating to modern industrial biotechnology.

Unit 2: Fermentation processes [8L]
General requirements of fermentation processes; Isolation, preservation and improvement of industrially important micro- organisms, development of inoculum for industrial fermentations. Different types of fermentations: Batch, Fed Batch and Continuous, Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations Components of a typical bio-reactor, Types of bioreactors-Laboratory, pilot- scale and production fermenters, constantly stirred tank and air-lift

fermenters, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration.

Unit 3: Basic Bioreactor Design and operations [6L]

Mechanical design of reactors, heat transfer and mass transfer equipment; Design considerations for maintaining sterility of process streams and process equipment, Spectrum of basic bioreactor operations: Enzyme immobilization techniques; Bioconversion using immobilized enzyme preparation; Bioconversion in batch, Fed-batch and continuous bioreactors; Mass transfer in immobilized cell/enzyme reactor

Unit 4: Metabolic Stoichiometry and Energetics [6L]

Stoichiometry of cell growth and product formation, elemental balances, degrees of reduction of substrate and biomass available, electron balances, yield coefficient of biomass and product formation, maintenance coefficients, energetics analysis of microbial growth and product formation, oxygen consumption and heat evolution in aerobic cultures, thermodynamic efficiency of growth.

Unit 5: Media Design and Sterilization for Fermentation Process [6L]

Designing of media for fermentation processes, Types of media, design and usage of various commercial media for industrial fermentations, thermal death kinetics of microorganisms, batch and continuous heat sterilization of liquid media, filter sterilization of liquid media, air, design of sterilization equipment.

Unit 6: Kinetics of Microbial Growth and Product Formation [6L]

Phases of cell growth in batch cultures, simple unstructured kinetic models for microbial growth, Monod model, growth of filamentous organisms. Growth associated (primary) and nongrowth associated (secondary) product formation kinetics, Leudeking-Piret models, substrate and product inhibition on cell growth and product formation.

Unit 7: Downstream Processing [10L]

Selection of unit operation with due consideration of physical, chemical and biochemical aspect of biomolecules, basic review of bioprocess designing ,Primary separation and recovery processes: Cell disruption methods for intracellular products, removal of insoluble, biomass (and particulate debris) separation techniques, flocculation and sedimentation, centrifugation and filtration methods, Product resolution / fractionation: Introduction to adsorptive chromatographic separations processes, electrophoretic separations, hybrid separation technologies (electrochromatography), Product finishing: precipitation/crystallization, mixing, dialysis, distillation and drying. Ultracentrifugation as a separation technique for fractionation of cells and proteins, Introduction to Process Analytical Technology (PAT) and Quality by Design (QbD). Scale down, monitoring and Validation of bioprocesses.

Suggested Books:

1. Stanbury, P.F., Whitaker, A., & Hall, S.J. (2016). Principles of Fermentation Technology (3rd ed.). Butterworth-Heinemann.

2. Shuler, M.L., & Kargi, F. (2017). Bioprocess Engineering: Basic Concepts (3rd ed.). Prentice Hall.
3. Casida, L.E. (1984). Industrial Microbiology. Wiley Eastern Ltd.
4. Prescott, S.C., & Dunn, C.G. (2004). Industrial Microbiology (4th ed.). CBS Publishers.
5. Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. (2001). Microbiology (5th ed.). Tata McGraw-Hill.

CC-12: Bioinformatics and Biostatistics
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1	Understand the basic concept of bioinformatics and its significance in biological data analysis.
CO 2	Understand basic algorithms and methodologies used in pairwise and multiple sequence alignments.
CO 3	Understand the basic concept of biostatistics and its significance in biological data analysis.
CO 4	Understand basic algorithms and methodologies used in Optimization Of process parameters. To apply statistics to the experiments being carried out and principles of statistics for designing microbiological experiment, statistical analysis, and interpretation of results
CO 5	To get familiar with various computation tools of biostatistics

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	3	3	-	3	1	3
CO 2	3	3	3	-	3	1	3
CO 3	3	3	2	2	3	2	3
CO 4	3	3	2	3	3	2	3
CO 5	3	3	2	3	3	2	3
Average CO	3	3	2	2	3	2	3

Component: Theory

Unit I: Introduction to Unix & C Programming [10L]

Introduction to command-based operating system, Unix basics: file system, commands (ls, cd, cp, mv, rm, mkdir, pwd), Text editors: nano, vim, or gedit, File permissions and directory structure, C Programming Fundamentals, C Programming Basics: Variables, constants, and data types and conversion, Conditional statements: if-else statements, Looping constructs: while, for, do loops.

Unit II: Fundamentals of Bioinformatics: Databases and Sequence Analysis [7L]

Scope and applications of Bioinformatics, Introduction to Biological database: Introduction to sequence data bank - Uniprot-KB, NBRF-PIR, SWISSPORT, EMBL, DDBJ. Structural database - PDB, NDB, PubChem. Biological background for sequence analysis, Basic concepts of sequence similarity and alignment, Scoring matrices: PAM, BLOSUM, Pairwise alignment: Needleman-Wunsch, Smith-Waterman algorithm, Multiple sequence alignment: CLUSTALW, MUSCLE, Construction of Phylogenetic tree.

Unit III: Structural Bioinformatics [7L]

Introduction to molecular visualization software (e.g., PyMOL, VMD), Sequence-structure relationships, Homology modeling and comparative protein structure prediction, Molecular docking and its application, Basics of molecular dynamics simulations.

Unit IV: Statistical Methods [8L]

Measures of Central tendency and Dispersion; Properties of Standard Normal Distribution, Normal Approximation to the Binomial Distribution, Normal Approximation to the Poisson Distribution, Permutations and Combinations, Hypothesis testing, Tests of significance: Student's t test, F-statistics, Chi square test.

Unit V: Regression and Correlation Analysis [8L]

Regression and Correlation Methods: General Concepts, Fitting Regression Lines— The Method of Least Squares, Inferences About Parameters from Regression Lines, Assessing the Goodness of Fit of Regression Lines, The Correlation Coefficient, Statistical Inference for Correlation Coefficients, Multiple Regression

Unit VI: Analysis of Variance and Experimental Design [8L]

Introduction to the One-Way Analysis of Variance: One-Way ANOVA—Fixed Effects Model, Hypothesis Testing in One-Way ANOVA, Comparisons of Specific Groups in One-way ANOVA, Two-Way ANOVA, The Kruskal-Wallis Test; Statistical optimization of process parameters: Factors in Biological Systems, Steps in Designing an Experiment, Response Surface methods; ANOVA Post Hoc Tests.

Suggested Books

1. Pevsner, J. (2009). Bioinformatics and Functional Genomics (2nd ed.). Wiley-Blackwell.
2. Campbell, A.M., & Heyer, L.J. (2006). Discovering Genomics, Proteomics and Bioinformatics (2nd ed.). Benjamin Cummings.
3. Kallen, A. (2011). Understanding Biostatistics. Brooks/Cole.
4. Bailey, N.T.J. (2000). Statistical Methods in Biology (3rd ed.). Cambridge University Press.
5. Khan, I.A. (2008). Fundamentals of Biostatistics. Ukaaz Publications.
6. Lachin, J.M. (2011). Biostatistical Methods: The Assessment of Relative Risks (2nd ed.). Wiley.
7. Ghosh, Z., & Mallick, B. (2008). Bioinformatics: Principles and Applications. Oxford University Press.

CC-13: Developmental Biology

Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1	Find how the development takes place in animals and plants.
CO 2	Outline the basic concepts of animal and plant reproduction and development.
CO 3	Identify the structural and functional requirements and the processes for animal and plant reproduction and development.
CO 4	Compare the interrelations of the structures and processes of animal and plant development.
CO 5	Explain the integrated responses of the animal and plant reproductive and developmental processes.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	2	2	2	2	2
CO 2	3	2	2	2	2	2	2
CO 3	3	3	3	3	3	3	3
CO 4	2	3	3	2	3	2	3
CO 5	2	2	3	3	3	2	3
Average CO	3	2	3	2	3	2	3

Component: Theory

Unit 1 **[4L]**

Introduction to Developmental Biology and Evolutionary Perspective

History and scope of developmental biology, Recapitulation theory, Sexual vs. asexual reproduction: Evolutionary and developmental consequences, Significance in biotechnology: Cloning and developmental plasticity

Unit 2 **[8L]**

Core Developmental Concepts

Potency, determination, competence, commitment, Morphogenetic fields and gradients, Induction, cell fate, Stem cells: Types, plasticity, and regenerative applications, Concepts of apoptosis, senescence, and regeneration, Developmental anomalies

Unit 3 **[12L]**

Gametogenesis, Fertilization, and Placentation

Spermatogenesis and oogenesis: Stages, hormonal control, and significance, Egg polarity and maternal determinants, Sperm-egg recognition and fusion, Egg activation and zygote formation, Placentation in mammals: Types, structure and function of placenta, maternal-foetal exchange mechanisms

Unit 4 **[6L]**

Cleavage, Gastrulation, and Germ Layer Formation

Blastula formation and significance, Cleavage formation and gastrulation, Gastrulation mechanisms in frog, chick, and sea urchin, Germ layer and pattern formation, Morphogenic gradients

Unit 5 **[6L]**

Organogenesis and Differentiation

Eye lens induction and limb development, Neurulation and early CNS development, Vulva development in *C. elegans,* Mechanisms of regeneration: Planarians, amphibians, Neuronal differentiation and migration

Unit 6 **[6L]**

Reproduction and Embryogenesis in Plants

Ovule development and megasporogenesis, Pollination and fertilization mechanisms, Double fertilization, Zygote and embryo development

Unit 7 **[6L]**

Plant Organ Development and Patterning

Seed and fruit development, Root-shoot apical meristems: Structure and function, Patterning of plant organs, ABC model of floral development, Role of phytohormones and signalling in development, Senescence in plants

Suggested Books

1. Gilbert, S.F. (2013). Developmental Biology (10th ed.). Sinauer Associates.
2. Wolpert, L., Tickle, C., Arias, A.M. (2015). Principles of Development (5th ed.). Oxford University Press.
3. Slack, J.M.W. (2012). Essential Developmental Biology (3rd ed.). Wiley-Blackwell.
4. Taiz, L., Zeiger, E., Møller, I.M., & Murphy, A. (2015). Plant Physiology and Development (6th ed.). Sinauer Associates.
5. Raghavan, V. (2000). Developmental Biology of Flowering Plants. Springer.

CC-14: Pharmaceutical Science and Drug Delivery

Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1	Understand the basic concepts, routes, and forms of drug administration.
CO 2	Describe principles and techniques involved in rational drug discovery and screening.
CO 3	Explain the concepts of bioavailability and bioequivalence with related assessment methods.
CO 4	Analyze pharmacokinetic models and interpret drug absorption and elimination data.
CO 5	Illustrate drug-receptor interactions, dose-response relationships, and pharmacodynamic principles.
CO 6	Identify and evaluate strategies for controlled and targeted drug delivery systems.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	1	2	1	1	2
CO 2	3	2	2	3	2	1	3
CO 3	3	1	2	3	1	1	2
CO 4	3	1	3	3	2	1	2
CO 5	3	2	2	2	1	1	2
CO 6	3	2	3	3	2	1	3
Average CO	3	2	2	3	2	1	3

Component: Theory

Unit 1: Basics of Pharmacology [6L]

Drug Nomenclature, Prescription drugs and OTC drugs, Orphan Drugs, Dosage forms of Drugs: Solid, Liquid, Semisolid, Gases and Volatile, Routes of Drug administration: Local and Systemic (Oral, Sublingual, Rectal, Cutaneous, Inhalation, Nasal, Parenteral)

Traditional drug discovery vs rational drug discovery; rational drug discovery pipeline; concept of target based drug design and target discovery; role of plant biotechnology in edible vaccine development.

Unit 2: Principles of Drug discovery [10L]

Screening and designing, Random and non-random screening, Natural sources (plant derived, microbial metabolites, marine invertebrates, Chemical approaches), Drug discovery: Hit conformation, Hit expansion, Lead optimization. Molecular modelling. Combinatorial chemistry (combinatorial synthesis, split synthesis, Encoding combinatorial libraries, Non peptidal synthesis). Types of combinatorial synthesis (SAR by NMR and MS, peptidomimetics). Pre-Clinical Development, Preclinical Toxicology testing, Clinical Trials

Unit 3: Bioavailability and bioequivalence [2L]

Definitions, federal requirements, methods of determination of bioavailability using blood and urinary excretion data. Protocol design for bioavailability assessment. Methods for bioequivalence determination.

Unit 4: Pharmacokinetic characterization of drugs [10L]

Pharmacokinetics of drugs following one/ two compartment open models with first order elimination kinetics as applied to rapid intravenous injection, Intravenous transfusion and oral administration. Determination of absorption rate constant using Wagner-Nelson, Loo Riegelman methods. Flip-flop models, method of residual. Urinary excretion data and its application in pharmacokinetic characterization of drugs. Pharmacokinetics of multiple dosing. Physiologic pharmacokinetics models: Mean Residence Time; Statistical Moment Theory; Application and limitations of physiologic pharmacokinetic models.

Unit 5: Pharmacodynamics [8L]

Principles of drug action, Mechanism of drug action, Receptors - Agonist, partial agonist, inverse agonist, antagonist, Receptors - Transducer mechanism. Dose-response relationship, Drug efficacy & potency, Therapeutic index, LD 50 & ED 50, Synergism and Drug antagonism. Factors modifying drug action.

Unit 6: Controlled drug delivery systems [12L]

Introduction, terminology/definitions and rationale, advantages, disadvantages, selection of drug candidates. Approaches to design controlled release formulations based on diffusion, dissolution and ion exchange principles. Physicochemical and biological properties of drugs relevant to controlled release formulations

Polymers: Introduction, classification, properties, advantages and application of polymers in formulation of controlled release drug delivery systems. Targeted drug Delivery: Concepts and approaches advantages and disadvantages, introduction to liposomes, niosomes, nanoparticles, monoclonal antibodies and their applications.

Suggested Books

1. Tripathi, K.D. (2019). Essentials of Medical Pharmacology (8th ed.). Jaypee Brothers Medical Publishers.
2. Rang, H.P., Dale, M.M., Ritter, J.M., Flower, R.J., & Henderson, G. (2015). Rang and Dale's Pharmacology (8th ed.). Elsevier Health Sciences.
3. Patrick, G.L. (2017). An Introduction to Medicinal Chemistry (6th ed.). Oxford University Press.
4. Brahmankar, D.M., & Jaiswal, S.B. (2015). Biopharmaceutics and Pharmacokinetics: A Treatise (2nd ed.). Vallabh Prakashan.
5. Lemke, T.L., Williams, D.A., Roche, V.F., & Zito, S.W. (2012). Foye's Principles of Medicinal Chemistry (7th ed.). Lippincott Williams & Wilkins.

CC-15: Advance Biotechnology and Tissue Culture
Credit: 4 (L3 T1 P0); Lectures: [48 L]

Course Outcomes:

CO 1	Gain an advanced level of understanding on the technical insight into plant tissue culture and genetic engineering.
CO 2	Understand the genome assembly of the model organisms used in plant transgenesis and its significance.
CO 3	Gain an advanced level of understanding on the technical insight and applications of animal cell culture.
CO 4	Identify and acquire skills on methods for genetic engineering of animals, embryo technology and learn applications and importance of animal transgenesis technology in human welfare including its ethical concerns.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	3	2	2	3	2
CO 2	3	3	3	3	2	3	3
CO 3	3	3	3	3	2	3	3
CO 4	3	3	3	3	2	3	3
Average CO	3	3	3	3	2	3	3

Component: Theory

Unit 1: Plant Tissue Culture [10L]
Basic sterilization techniques used in plant tissue culture; Explant and callus culture; Different culture media and growth regulators**.**

Unit 2: Model organisms used in plant transgenesis: **[10L]**
Rice, Arabidopsis, Wheat, Maize and Brachypodium. Plant transformation techniques: vectors used in PTC, gene transformation techniques, concept of Agrobacterium mediated gene transfer, Floral dip method for Arabidopsis transformation; Protoplast isolation, transformation and regeneration. GM crops and its social and ethical issues. Debate over GM crops.

Unit 3: Genetic Manipulation in Animal: Model Systems and Applications [6L]
Introduction to methods of genetic manipulation in different model systems. Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model.

Unit 4: Animal Cell Culture [8L]
Brief history of animal cell culture, Different type of cell culture media, growth supplements, serum free media, balanced salt solution, other cell culture reagents, culture of mammalian cells, tissues and organs, primary culture, secondary culture, continuous cell lines, suspension cultures, Cell cloning and selection; Cell synchronization, embryonic and adult stem cell culture; its applications, Characterization and maintenance of cell lines, application of animal cell culture.

Unit 5: Transgenic Animals & Reproductive Biotechnology: Methods and Applications [8L]

Transgenesis: transfection and Transformation of cell, Vectors for animal cells: SV40, adenovirus vectors, baculovirus, lenti virus, poxyvirus. Super ovulation, artificial insemination. In-vitro fertilization, embryo recovery and culture of embryos, Cryopreservation of embryos; embryo transfer technology, transgenic manipulation of animal embryos, Applications of transgenic animal technology. Animal cloning - basic concepts. Ethical issues in animal biotechnology.

Unit 6: Tissue Engineering [6L]

Historical overview and fundamentals of tissue engineering; tissue dynamics and homeostasis; biomaterials for tissue engineering: properties and types of scaffolds; role of growth factors and cell-scaffold interactions; skin and vascular tissue engineering; bone, cartilage, and nerve tissue engineering; emerging applications (muscle, liver, kidney); ethical and regulatory challenges in tissue engineering.

Suggested Books:

1. Hammod, J., McGarvey, P., & Yusibov, V. (2000). Plant Biotechnology: New Products and Applications. Springer Nature.
2. Chawla, H. S. (1998 Biotechnology in Crop Improvement. International Book Distributing Company.
3. Gupta, P. K. (Year). Biotechnology and Genomics. Rastogi Publications.
4. ICAR Publications & Information Division, New Delhi. Handbook of Plant Tissue Culture.
5. Singh, B. D., & Singh, R. P. (Year). Biotechnology. Kalyani Publishers.
6. Chawla, H. S. (2003). Introduction to Plant Biotechnology (2nd ed.). Oxford and IBH Publishers.
7. Dubey, R. C. Text Book of Biotechnology. A. S. Chand & Co Ltd, New Delhi.
8. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.

CC-16: MSc. Biotechnology Practical-III
Credit: 4 (L0 T0 P8)

CO 1	Apply experimental approaches in plant physiology and molecular biology to study developmental responses and identify gene functions using model plants.
CO 2	Utilize bioinformatics tools for sequence retrieval, multiple sequence alignment, phylogenetic analysis, structural prediction, and molecular docking.
CO 3	Operate and monitor laboratory-scale fermentation systems and perform scale-up, product recovery, and purification processes.
CO 4	Conduct advanced biochemical techniques such as enzyme immobilization and nanoparticle synthesis, along with their characterization.
CO 5	Analyze experimental data using statistical tests and design of experiments (DOE) for scientific interpretation and bioprocess optimization.

Course Outcome	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	3	2	3	2	3	2	2
CO 2	3	3	2	3	2	2	3
CO 3	3	3	3	2	3	2	3
CO 4	3	3	3	2	3	2	3
CO 5	3	3	3	2	3	1	3
Average CO	3	3	3	2	3	2	3

Component: Practical
List of Experiments:

1. To investigate the effect of light on the early developmental stages of Arabidopsis thaliana seedlings by assessing morphological differences under varying light conditions.
2. Identification of Arabidopsis Lines with T-DNA Insertion in a Gene of Interest and application of PCR based strategy to isolate the homozygous mutant lines.
3. Use of Public Domain Interfaces for downloading different DNA and Protein sequences from authenticated Databases. Perform multiple sequence alignment (MSA) by using CLUSTALW and construct phylogenetic tree using MEGA software.
4. Retrieve a protein sequence from the Protein Data Bank (PDB), predict its 3D structure through homology modeling, and perform molecular docking with a ligand using AutoDock Vina to study protein-ligand interactions.
5. Laboratory fermenter operation, scale-up of selected strain.
6. Production and purification of alcohol and acids.
7. Enzyme immobilization and its characterization.
8. Test of Significance: Students t test, F test, Chi square test.
9. Process parameter optimization using statistical design of experiments (DOE).
10. Synthesis of polymeric nanoparticles and its characterization.
11. Comparative analysis of drugs.

Semester - IV

CC-17: Biotechnology Master Project/Dissertation
Credit: 12 (L0 T0 P24)

Component: Project

Course Prerequisite: Student should have passed all theory and practical courses. A basic knowledge about the subject and discipline of interest should be there. Student must be aware of good laboratory practices with skills to perform laboratory experiments.

Course Outcome: At the end of this course a student will be able to understand and analyse various aspect of biological world. This will also help the student to decide their field of interest for academic and industrial purpose.