ANNEXURE – III B

DAYANANDA SAGAR UNIVERSITY

SCHOOL OF BASIC & APPLIED SCIENCES

SCHEME & SYLLABUS
FOR
MASTER OF SCIENCE (M.Sc.) – 2025-2027

SPECIALIZATION: BIOTECHNOLOGY

(With effect from 2025-26)
(From I to IV Semesters)

DAYANANDA SAGAR UNIVERSITY
INNOVATION CAMPUS, KUDLU GATE, HOSUR ROAD,
BENGALURU -560114.

DAYANANDA SAGAR UNIVERSITY
SCHOOL OF BASIC AND APPLIED SCIENCES
PROPOSED SCHEME- M. SC. BIOTECHNOLOGY- 2025-26 ONWARDS

I SEM – M.Sc.- BIOTECHNOLOGY

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR/ AU	SCHEME OF TEACHING						SCHEME OF EVALUATION	
					L	T	P	S/P	C		CIA	END EXAM
1	207	25MSC5101	Essentials of Chemistry	CR	4	-	-	-	4		60	40
2	207	25MBT5101	Biomolecules & Metabolism	CR	4	-	-	-	4		60	40
3	207	25MBT5102	Cell Biology	CR	4	-	-	-	4		60	40
4	207	25MBT5103	Advanced Molecular Biology	CR	4	-	-	-	4		60	40
5	207	25MBT5104	Multiomics & System Biology	CR	2	-		-	2		60	40
6	207	25MSC5102	Biostatistics	CR	2	-	-	-	2		60	40
7	207	25MBT5171	Biochemical Analysis	CR	-	-	6	-	3		60	40
8	207	25MBT5172	Techniques in Cell and Molecular Biology Lab	CR	-		6		3		60	40
			GRAND TOTAL = 800		**20**	**-**	**6**	**-**	**26**		**480**	**320**

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

II SEM – M.Sc.- BIOTECHNOLOGY

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR/ AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
					L	T	P	S/P	C	CIA	END EXAM
1	207	25MBT5201	Fundamentals of Microbiology	CR	4	-	-	-	4	60	40
2	207	25MBT5202	Immunology	CR	4	-	-	-	4	60	40
3	207	25MBT5203	Enzymology & Bioanalytical techniques	CR	4	-	-	-	4	60	40
4	207	25MBT5204	Genetic Engineering for Synthetic Biology	CR	4	-	-	-	4	60	40
5	207	25MBT5205	Food & Environmental Biotechnology	CR	4	-	-	-	4	60	40
6	207	25MBT5206	AI & ML for Biologist	CR	2	-	-	-	2	60	40
7	207	25MBT5271	Integrated Bioanalytical Techniques- Practical	CR	-	-	6	-	3	60	40
8	207	25MBT5272	Techniques in Microbiology and sustainable biotechnology- Practical	CR	-	-	6	-	3	60	40
			GRAND TOTAL = 800		**22**	**-**	**12**	**-**	**28**	**480**	**320**

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

III SEM – M.Sc.- BIOTECHNOLOGY

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR/ AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
					L	T	P	S/ P	C	CIA	END EXAM
1	207	25MBT5301	Industrial Biotechnology	CR	4	-	-	-	4	60	40
2	207	25MBT5302	Plant & Agricultural Biotechnology	CR	4	-	-	-	4	60	40
3	207	25MBT5303	Animal Biotechnology & Regenerative medicine	CR	3	-	-	-	3	60	40
4	207	25MBT5304	Medical Biotechnology	CR	3	-	-	-	3	60	40
5	207	25MBT5305	System biology & Drug discovery	CR	3	-	-	-	3	60	40
6	207	25MSC5301	Research Methodology, Scientific writing and IPR	CR	3	-	-	-	3	60	40
7	207	25MBT5306	Nanobiotechnology	CR	2	-	-	-	2	60	40
8	207	25MBT5307	Clinical research & Toxicology	CR	2	-	-	-	2	60	40
9	207	25MBT5371	Techniques in Industrial and Plant Biotechnology- Practical	CR	-		6		3	60	40
10	207	25MBT5372	Techniques in Translational Biotechnology- Practical	CR	-		6		3	60	40
			Grand Total= 1000		**24**	**-**	**12**	**-**	**30**	**600**	**400**

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

IV SEM – M.Sc.- BIOTECHNOLOGY

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR/ AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
					L	T	P	S/P	C	CIA	END EXAM
1	207	25MSC5401	Project	CR	4	-	-	36	14	60	40
2	207	25MSC5402	MOOC/NPTEL/ Swayam	CR	4	-	-	-	2		
			Grand Total= 400					**36**	**16**		

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

SL	CREDIT (CR)	MARKS	
		CIA MARKS	END EXAM MARKS
1	4	60	40
2	3	60	40
2	2	30	20
3	14	240	160

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MSC5101**					
TITLE OF THE COURSE	**ESSENTIALS OF CHEMISTRY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To help students grasp fundamental chemical principles—such as stoichiometry, chemical bonding, electrochemistry, and organic reactivity—specifically as they relate to biological systems.
- To enable students to apply theoretical knowledge in solving quantitative and mechanistic problems involving solution chemistry, redox reactions, and biomolecular interactions.
- To introduce students to the chemical structures and reaction mechanisms within biological contexts, including enzymatic catalysis, metabolic pathways, and molecular transport.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will become familiar with fundamental chemical concepts, including mole calculations, acid-base theories, bonding types, and stereochemistry, particularly as they apply to biological molecules.	L2
CO2	Students will be able to apply chemical equations and quantitative tools—such as dilution formulas (e.g., N1V1=N2V2) and the Henderson-Hasselbalch equation—along with mechanistic understanding, to tasks such as buffer preparation, molecular weight determination.	L3
CO3	Students will be able to analyze the roles of metals in biological systems, the influence of stereochemistry on bioactivity, and reaction mechanisms related to metabolic processes.	L3

COURSE CONTENT:

MODULE 1: STOICHIOMETRY AND CHEMICAL BONDING **14Hrs**

Stoichiometry: Atomic weights, molecular weights, mole concept, molarity, molality, normality, mole fraction, ppt, ppb and ppm. Numerical problems related to the above concepts. Classification, preparation and dilution of reagents/solutions. Preparation of ppm level solutions from source materials (salts), conversion factors.

Chemical bonding: Ionic bonds, Covalent bonds, Vander walls forces, Electrostatic interactions, Hydrophobic interactions, Hydrogen bonding & their relevance in biological systems, importance of water in biological systems. Coordination bonds in biomolecules - bonding of iron in haemoglobin, magnesium in chlorophyll. Types of chemical bonds in biological molecules (Glycosidic, phosphdiester, peptide).

MODULE 2: PHYSICAL CHEMISTRY	**14Hrs**
Bio-Electrochemistry: Oxidation and Reduction reactions, Electrode potential, standard & reference electrode, calculation of biological standard potential & biological equilibrium constant, Nernst's' equation. Biological electrochemical series (ETC). Liquids and solutions: Acid and bases (Brønsted-Lowry Theory, Lewis Theory), pKa, pKb, pH, pOH, preparation of buffers, Henderson-Hasselbalch equation and numerical problems associated with buffer preparation. Density and Relative Density, Viscosity, Surface tension, Colligative properties (brief). Calculation of molecular weight of proteins and nucleic acids.	
MODULE 3: BIOINORGANIC CHEMISTRY	**14Hrs**
Stereochemistry: Introduction, Different types of isomerism, chirality & optical activity (enatiomers and diastereoisomers; Fischer, Sawhorse, and Newman Projection formulae of simple molecules containing one and two asymmetric carbon atom). Symmetry elements, E and Z, D and L nomenclature (for carbohydrates and aminoacids only). Role of metals: Introduction, Classification, role of metal in various biological system: Enzyme Activity (zinc with carbonic anhydrase) Examples for metal activated enzymes and metalloenzymes, Energy Transfer and Redox Reactions (cytochrome c complex- Fe), Oxygen Transport (Iron in hemoglobin, Copper in hemocyanin) Nerve Signal Transmission (role of Sodium and potassium ions), Structural Roles, Metallothionins, metals as essential nutrients, nutritional Immunity. Regulatory Roles (Magnesium and calcium ions play crucial roles in cell regulation and signalling pathways.	
MODULE 4: BIOORGANIC CHEMISTRY	**14Hrs**
Basics: Properties of carbon, brief classification of organic compounds based on functional groups with examples. Delocalisation of electrons: Inductive effect, electrometric effect, resonance (mesomeric effect, EWG and EDG, +M and –M effects). Curly arrow rules in representation of mechanistic steps, types of bond cleavage; electrophiles, nucleophiles, Reactive intermediates: carbocations, carbanions, free radicals and carbenes– generation, structures, stability and examples. Reaction mechanisms: SN1 (formation of PRPP in nucleotide biosynthesis), SN2 (eg. DNA polymerization, phosphorylation), E1 (histidine/aromatic aminoacid biosynthesis), E2 reactions (fatty acid biosynthesis). Metabolic reactions- aldol condensation (collagen), esterification of acids (triglycerides), oxidation and reduction reactions (NAD^+ to NADH during cellular respiration.).	
TEXT BOOKS/ REFERENCES:	
1. General Chemistry (2022) Linus Pauling, Dover Publications, New York, USA. 2. Quantitative Chemical Analysis 10th Edition (2022) Daniel C. Harris, Macmillan Learning, New York, USA. 3. Lehninger Principles of Biochemistry 8th Edition (2021) David L. Nelson and Michael M. Cox, W.H. Freeman & Company, New York, USA. 4. Physical Chemistry for the Life Sciences 2nd Edition (2014) Peter Atkins and Julio de Paula, Oxford University Press, Oxford, UK. 5. Principles of Physical Chemistry (2023) Puri, Sharma, and Pathania, Vishal Publishing Co., Jalandhar, India.	

6. Biophysical Chemistry: Principles and Techniques (2022) Upadhyay, Upadhyay, and Nath, Himalaya Publishing House, Mumbai, India.
7. Bioinorganic Chemistry: A Short Course 2nd Edition (2014) Rosette M. Roat-Malone, Wiley, Hoboken, USA.
8. Inorganic Chemistry 6th Edition (2021) Gary L. Miessler, Paul J. Fischer, and Donald A. Tarr, Pearson Education, Boston, USA.
9. Stereochemistry of Organic Compounds 1st Edition (1994) Ernest L. Eliel and Samuel H. Wilen, Wiley India Pvt. Ltd., New Delhi, India.
10. Organic Chemistry 9th Edition (2021) Paula Yurkanis Bruice, Pearson Education, Boston, USA.
11. Organic Chemistry 8th Edition (2022) Morrison and Boyd, Pearson India Education Services Pvt. Ltd., Noida, India.
12. Principles of Biochemistry 8th Edition (2021) David L. Nelson and Michael M. Cox, W.H. Freeman & Company, New York, USA.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MBT5101**					
TITLE OF THE COURSE	**BIOMOLECULES AND METABOLISM**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To create in depth understanding of the fundamentals of biomolecules
- To impart knowledge about structural and functional classification of biomolecules, as well as their biological significance
- To impart a fundamental understanding of the metabolism of carbohydrates, amino acids, nucleotides, and lipids

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to understand the structure of biomolecules and their function	**L2**
CO2	Students will apply knowledge of biomolecules to interpret their properties and biological roles	**L3**
CO3	Students will be able to analyze the pathways involved in the metabolism of biomolecules	**L4**

COURSE CONTENT:

MODULE 1: CARBOHYDRATES AND METABOLISM — **14 Hrs**

Simple Carbohydrates: Structure and classification of carbohydrates. Configuration and conformational aspects of monosaccharides. Glycosidic linkages in disaccharides.

Complex Carbohydrates: Homopolysaccharides and heteropolysaccharides - starch, glycogen, cellulose chitin, glycosaminoglycans and proteoglycans - O and N linked oligosaccharides.

Metabolism: Glycolytic pathway. Gluconeogenesis pathway. TCA cycle. HMP pathway, Cori's cycle, Brief scheme of glycogen metabolism.

Disorders: Diabetes mellitus, Glycogen storage diseases. Overview of dietary interventions.

MODULE 2: PROTEIN STRUCTURE AND METABOLISM — **14 Hrs**

Primary structure – Structure, classification and properties of amino acids, Peptide bond.

Secondary structure: α-helix, β pleated sheet, Ramachandran plot. Super secondary structures: Motifs and domains.

Tertiary structure: Interactions stabilizing tertiary structure.

Quaternary structure: Haemoglobin Structure and mechanism of co-operativity. Protein-ligand interactions

Protein Classification: fibrous proteins (α-keratin, silk fibroin and collagen), globular proteins (Myoglobin and chymotrypsin).

Amino acid metabolism: General metabolic reaction of amino acids– transamination, glucose – alanine cycle, oxidative deamination (glutamate dehydrogenase), minor pathways of amino acid degradation – trans deamination, amino acid oxidase, and non – oxidative deamination. Urea cycle, Biosynthesis and degradation of essential amino acids overview (Glutamate and Glutamine).

Disorders of amino acid metabolism: Phenylketonuria, Alkaptonuria and protein folding disorder-proteinopathy. Overview of dietary interventions.

MODULE 3: LIPIDS AND METABOLISM	**14 Hrs**

Lipids: Classification, Structure, and biological importance of lipids. Simple lipids - free fatty acids (saturated, cis-unsaturated, trans-unsaturated) acyl glycerol's. Complex lipids - phospholipids, sphingolipids, galactolipids and Derived lipids – sterols and eicosanoids.

Lipid Metabolism: Oxidation of fatty acids: beta oxidation. Cholesterol biosynthesis from Acetyl CoA, Importance of HMG CoA reductase. Degradation of triacylglycerol and phospholipids- lipases and phospholipases. Insoluble lipid mobilization by lipoproteins- chylomicrons, HDL, LDL, and VLDL. Scheme transport of cholesterol -LDL receptor pathway. Biological functions of VLDL, LDL and HDL.

Disorders of Lipid metabolism: Hyperlipidaemia, Lipoproteinemia. Overview of dietary interventions.

MODULE 4: NUCLEIC ACID AND METABOLISM	**14 Hrs**

Nucleic acids: Nucleosides, nucleotides and polynucleotides (DNA, RNA); Types of DNA (A, B and Z forms), Types of RNA (rRNA, mRNA, tRNA)

Nucleotide metabolism: Biosynthesis of purine and pyrimidine nucleotides (de-novo and salvage). Degradation of purine and pyrimidines.

Disorders of nucleotide metabolism: Lesch–Nyhan Syndrome, Gout. Overview of dietary interventions.

TEXT BOOKS/ REFERENCES:

1. Lehninger Principles of Biochemistry, DL Nelson, MM Cox, and AA Hoskins, 8th edition, W.H. Freeman & Company, 2021.
2. Harper's Illustrated Biochemistry, PJ. Kennelly, KM. Botham, Owen McGuinness, VW. Rodwell, and PA Weil, 32nd edition, McGraw-Hill Education, 2022.
3. Principles of Biochemistry, Donald Voet, Judith G. Voet, and Charlotte W. Pratt, 5th edition, John Wiley & Sons, 2018.
4. Biochemistry and Molecular Biology, William H. Elliott and Daphne C. Elliott, 6th edition, Oxford University Press, 2018.
5. Metabolism at a Glance, J.G. Salway, 4th edition, Wiley-Blackwell, 2017.
6. Biochemical Pathways: An Atlas of Biochemistry and Molecular Biology, Gerhard Michal and Dietmar Schomburg, 2nd edition, Wiley-VCH, 2012.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MBT5102**					
TITLE OF THE COURSE	**CELL BIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To understand the basic components and organisation of cells.
- To familiarize with cellular processes and function.
- To explain the principles and pathways of cell signalling, including receptor types, second messengers and cellular response.

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will understand the structure and function of key cellular components.	**L2**
CO2	Students will be able to explain the molecular mechanism that govern essential cellular processes.	**L3**
CO3	Students will be able to interpret the principles of cellular signalling.	**L3**

COURSE CONTENT:

MODULE 1: CELL TYPES, CELL CYCLE AND ITS CONTROL **14 Hrs**

Cell types: Structure of prokaryotic and eukaryotic cells, ultrastructure of animal and plant cell. Cell division and control: Mitosis, meiosis and their genetic significance. Cell cycle: Functional events of cell division and molecular mechanism of cell cycle, Control mechanisms: Role of cyclins, Cdks and inhibitors of cell cycle progression, Cell cycle check points, control of cell numbers in multicellular organisms, Cell death: Apoptosis and necrosis, related pathways, cell senescence.

MODULE 2: MEMBRANE TRANSPORT **14 Hrs**

Biological membranes: Structure and properties of membrane, membrane constituents- phospholipids, glycolipid, cholesterol, membrane proteins. Transport of nutrients- transport of ions and macromolecules, diffusion, osmosis, reverse osmosis; Types of transport mechanisms: active and passive transport, symport, antiport, co-transport, endocytosis and exocytosis; Transport Pumps and Proteins: Ionophores, permeases, Na+/K+ Pump, Ca2+ Pump. ABC transporter in multidrug resistance.

MODULE 3: CYTOSKELETON AND CELL-CELL INTERACTIONS **14 Hrs**

Cytoskeletal elements: Microtubules, microfilaments and intermediate filaments, microtubule polymerization dynamics, MAPs, actin polymerization dynamics, muscle contraction, Cilia and flagella - structure and function. Cytoskeletal diseases, Extracellular matrix (ECM) and its biomolecules: Collagen, proteoglycans, fibronectin and laminin. Cellular junctions: desmosomes, tight junctions, gap junctions and plasmodesmata.

MODULE 4: CELL SIGNALING AND ANTIOXIDANT DEFENCE SYSTEM	14 Hrs
Cell signalling: Principles of cell signalling, intercellular signalling: endocrine, paracrine and autocrine signalling, Extracellular Messengers & their receptors, signalling via G-protein coupled receptors, enzyme linked receptors and kinase receptors. Role of GPCRs in sensory perceptions. (Ca2+Cyclic modulators – cAMP, cGMP, IP3, DAG, Nitric Oxide). Role of secondary messengers, Regulation of Glucose levels. Antioxidant defence system: Free radicals-ROS, RNS, effect of free radicals on proteins, lipids and nucleic acids, and their clinical importance. Mechanism of antioxidant defence system (Glutathione, catalase, SOD, peroxidase).	

TEXT BOOKS/ REFERENCES:

1. Essential Cell Biology, Bruce Alberts, Karen Hopkin, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter, Garland Science, 4th edition, 2013.
2. Karp's Cell and Molecular Biology: Concepts and Experiments, Gerald Karp, Janet Iwasa, Wallace Marshall, Wiley, 9th edition, 2021.
3. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter, Garland Science, 6th edition, 2014.
4. Molecular Cell Biology, Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Kelsey C. Martin, Michael Yaffe, Angelika Amon, W.H. Freeman, 9th edition, 2021.
5. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, W.H. Freeman, 8th edition, 2021.
6. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, Gregory J. Gatto Jr., Justin Hines, W.H. Freeman, 10th edition, 2023.
7. Harper's Illustrated Biochemistry, Victor W. Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil, McGraw-Hill Education, 32nd edition, 2022.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MBT5103**					
TITLE OF THE COURSE	**ADVANCED MOLECULAR BIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To introduce basic concepts of central dogma and flow of genetic information
- To give substantial knowledge on the key pathways/events involved in gene expression and its regulation in prokaryotes and eukaryotes
- To provide knowledge on model organisms and key techniques that can be applied for gene and protein analyses

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will understand the key events of central dogma comprising mechanism of replication, transcription and translation	**L1**
CO2	Student will understand the molecular mechanisms of expression, regulation, and maintenance of genetic information, within a biological system	**L2**
CO3	Student will be able to critically think, use model organisms and apply techniques in the field of application of molecular biology	**L3**

COURSE CONTENT:

MODULE 1: DNA REPLICATION AND REPAIR **14Hrs**

Structure and functions of DNA: Watson and Crick model of DNA structure, A, B & Z forms of DNA, Supercoiled and relaxed DNA, Nucleosome structure and packaging of DNA into higher order structures, Denaturation and renaturation of DNA, Melting temperature (Tm), Hyperchromic effect.

Genome and its organisation: gene, coding sequence, regulatory sequence, intron, exon.

Mechanism of DNA Replication: Meselson & Stahl experiment, semi-conservative and semi-discontinuous replication, Unidirectional and bidirectional replication. Mechanism of DNA replication (prokaryotes & eukaryotes). Regulation of replication (prokaryotes and eukaryotes). Inhibitors of replication.

DNA damages and Repair mechanism (Excision repair -BER and NER, mismatch repair and SOS repair).

Note: Supplemented by research article

MODULE 2: GENE EXPRESSION – TRANSCRIPTION **14Hrs**

Structure and function of RNA and its types: mRNA, tRNA, rRNA and small RNA- (miRNA, siRNA, snRNA)

Prokaryotic Transcription: Bacterial RNA polymerase Components of basal transcriptional unit, prokaryotic promoters. Role of sigma factor in initiation, Mechanism of Initiation, Elongation and Termination (Rho dependent and Rho independent).

Eukaryotic Transcription: RNA polymerase, Mechanism of transcription (initiation, elongation, termination), Post transcriptional modifications of mRNA (5' cap formation, poly adenylation, mechanism of splicing), mRNA stability. Synthesis and processing of tRNA and rRNA. Inhibitors of transcription. RNA editing.

Note: Supplemented by research article

MODULE 3: GENE EXPRESSION- TRANSLATION	**14Hrs**

Protein synthesis: Genetic code, Wobble hypothesis. Components of Protein synthesis machinery: Charging of tRNA, aminoacyl tRNA synthetases, ribosome structure and assembly.

Mechanism of protein synthesis -initiation, elongation and termination (Prokaryotes & Eukaryotes), Codon usage, Inhibitors of protein synthesis, Post translational modifications of proteins.

Protein targeting and localization: Export of secretory proteins- signal hypothesis, transport and localization of proteins to mitochondria, chloroplast, peroxisomes and membrane.

Note: Supplemented by research article

MODULE 4: REGULATION OF GENE EXPRESSION IN PROKARYOTES AND EUKARYOTES	**14Hrs**

Regulation of prokaryotic gene expression: Operon concept, negative and positive regulation (lactose operon), Regulation of tryptophan operon by attenuation.

Regulation of eukaryotic gene expression: Epigenetic (DNA methylation, histone modification, chromatin remodelling, non -coding RNA, histone variants)

Gene Silencing: RNA silencing (siRNA and mi RNA), Applications of Antisense RNA.

Molecular Methods: PCR based identification of gene of interest, Quantification of gene expression using Quantitative PCR (qPCR), Next generation sequencing to analyse DNA (genomic) and RNA (transcriptomic); Mass Spectrometry-Based Protein Sequencing (LC-MS/MS). Chromatin immunoprecipitation (ChIP)- ChIP-seq & ChIP-chip for protein-DNA interaction. Transducers for biomolecular interaction analyses - electrochemical and optical signals.

Model organisms for studying Molecular Biology: *E. coli, S. cerevisiae, C. elegans, Drosophila, Zebrafish* and *Mouse.*

Note: Supplemented by research article.

TEXT BOOKS/ REFERENCES:

1. *Cell and Molecular Biology: Concepts and Experiments,* Gerald Karp, John Wiley & Sons, 6th edition, 2010.
2. Molecular Biology of the Gene, James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, Pearson, 7th edition, 2013.
3. Molecular Biology, Robert F. Weaver, McGraw-Hill Education, 5th edition, 2011.
4. Molecular Biology of the Cell Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter, Garland Science, 6th edition, 2014

5. Molecular Cell Biology, Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Kelsey C. Martin, Michael Yaffe, Angelika Amon, W.H. Freeman, 9th edition, 2021.
6. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto Jr., Lubert Stryer, W.H. Freeman, 8th edition, 2015.
7. Redefining fundamental concepts of transcription initiation in bacteria. Nature Reviews Genetics. (doi:10.1038/s41576-020-0254-8).
8. Molecular Biology: Principles of Genome Function**,** Nancy L. Craig, Rachel R. Green, Carol C. Greider, Gisela G. Storz, Cynthia Wolberger, Oxford University Press, 3rd ed, 2020.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MSC5102**					
TITLE OF THE COURSE	**BIOSTATISTICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	**28**	**2**

COURSE OBJECTIVES:

- Build a strong foundation in statistical theory and methods with a focus on applications in health sciences, clinical research, epidemiology, and public health
- Develop analytical skills to manage, analyze, and interpret biomedical data
- Enable critical evaluation of scientific literature and the application of appropriate statistical methodologies in research design and analysis

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	To use statistical tools proficiently for data management, analysis, and reporting	**L2**
CO2	Apply core statistical concepts and techniques in biological and health-related contexts	**L3**
CO3	Interpret and communicate statistical results clearly in written and oral form, suitable for scientific publications and presentations	**L4**

COURSE CONTENT:

MODULE 1: MEASURES OF CENTRAL TENDENCIES, DISPERSION AND CORRELATION — **14 Hrs**

Introduction to Bio-statistics and its significance, use of replicates, Tabulation, and graphical representations of data. Different models of data presentations. Frequency distribution. Measures of Central tendency: Arithmetic mean, mode & median. Measures of variability: Range, mean deviation, and percentiles. Standard deviation and co-efficient of variation, Standard error Properties of the data: linear regression and correlation-test of significance, skewness and kurtosis and their various measures, Simple linear correlation and regression analysis. Analysis of variance. Sampling methods and their significance.

MODULE 2: PROBABILITY DISTRIBUTIONS AND TESTING OF HYPOTHESIS — **14 Hrs**

Probability: Definition, types of events, sample space, conditional probability, addition and multiplication rules of probability and some simple problems. Probability distributions- Binomial, Poisson and Normal distributions with simple numerical. Testing of hypothesis: basic concepts and definitions, types of errors, confidence intervals. Tests based on Normal, student's t, chi-square and F distributions, interpretation of "p" value. Anova- one way and two- way, Statistical package- Features of statistical software, SPSS for various applications in Biostatistical program**.**

TEXT BOOKS/ REFERENCES:

1. Biostatistics: A Foundation for Analysis in the Health Sciences Daniel, W. W. 7th edition. Wiley India Pvt. Ltd., 2005.
2. Fundamentals of Biostatistics**.** Khan, I. A., Khanum, A., & Khan, S.**,** 6th edition, Ukaaz Publications, 2020
3. Statistics for Biologists. Campbell, R.C. Cambridge Univ. Press., 3rd edition, 2012.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MBT5104**					
TITLE OF THE COURSE	**MULTI OMICS & SYSTEM BIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	**28**	**2**

COURSE OBJECTIVES:

- **To provide foundational knowledge of multi-omics—including genomics, transcriptomics, proteomics, and metabolomics.**
- **To apply integrated multi-omics approaches to explore the intricacies of biological systems.**
- **To introduce the principles of systems biology for modelling and analysing biological networks.**
- **To enable students to interpret high-throughput data in a holistic and systems-level context.**

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will describe various omics technologies and their roles in systems biology	**L2**
CO2	Students will be able to analyze and interpret high-throughput omics data	**L4**
CO3	Students will be able integrate multi-omics datasets using bioinformatics tools and platforms	**L5**
CO4	Students will be able to construct systems-level models for understanding cellular processes and disease states	**L6**

COURSE CONTENT:

MODULE 1: OMICS AND NETWORK BIOLOGY **14 Hrs**

Introduction to Omics Technologies: Genomics: DNA sequencing technologies, genome assembly, and annotation (Bacteria), Metagenomics, Transcriptomics: RNA-seq, gene expression profiling, Proteomics: Mass spectrometry, protein quantification, Metabolomics, lipidomics, methylomics, and Epigenomics: Methods and data types.

Multi-Omics Integration and Network Biology: Preprocessing and quality control of sequencing and MS data Normalization and statistical testing. Differential gene/protein/metabolite expression analysis tools: Galaxy, Bioconductor, Metabo Analyst.

MODULE 2: APPLICATION OF MULTI-OMICS **14 Hrs**

Multi-Omics Integration and Network Biology Strategies for data integration: horizontal, vertical, and diagonal - Network biology concepts: nodes, edges, hubs, modules - Construction of gene regulatory, protein-protein interaction, and metabolic networks - Visualization and interpretation using Cytoscape and pathway databases (KEGG, Reactome).

Systems Biology Applications in Health and Disease.

Systems-level approaches in cancer, infectious disease, and metabolic disorders - Case studies in personalized medicine and biomarker discovery - Introduction to machine learning in systems biology Limitations, challenges, and future directions of multi-omics integration.

TEXT BOOKS/ REFERENCES:

1. Bioinformatics, Jonathan M. Keith, 2nd Edition, Humana Press, 2017.
2. Computer Methods for Macromolecular Sequence Analysis, Russell F. Doolittle, 1st Edition, Academic Press, 1996.
3. Introduction to Proteomics: Tools for the New Biology, Daniel C. Liebler, 1st Edition, Humana Press, 2002.
4. Bioinformatics and Functional Genomics, Jonathan Pevsner, 3rd Edition, Wiley, 2015.
5. Encyclopedia of Genetics, Genomics, Proteomics and Bioinformatics, Lynn B. Jorde et al. (Eds.), 1st Edition, John Wiley and Sons, 2005.
6. Metabolomics: Methods and Protocols, Wolfram Weckwerth, 1st Edition, Humana Press, 2007.
7. Transcriptomics: Expression Pattern Analysis, Virendra Gomase, Somnath Tagore, 1st Edition, VDM Publishing, 2009.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MBT5171**					
TITLE OF THE COURSE	**BIOCHEMICAL ANALYSIS- PRACTICAL**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	-	**-**	**6**	**-**	**72**	**3**

COURSE OBJECTIVES:

- To introduce students to essential chemical principles such as the preparation of buffers and the determination of pKa values
- To enable students with basic understanding of techniques used for estimation of biomolecules
- To familiarize students with the use of UV spectroscopy in determining the extinction coefficient of biomolecules (proteins, DNA, RNA)

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to prepare chemical buffer solutions and accurately determine the pKa	**L2**
CO2	Students will demonstrate a basic understanding of biomolecular detection techniques and apply selected methods to identify and analyse biomolecules	**L3**
CO3	Students will demonstrate the ability to operate a UV spectrophotometer, collect absorbance data, and calculate the extinction coefficient of biomolecules using Beer-Lambert's law	**L3**

LIST OF EXPERIMENTS

Chemistry

1. Preparations of Buffers.
2. Determination of pKa of a weak acid by pH metric method.
3. Determination of Phosphorus in aerated drinks
4. Determination of total hardness of water.
5. Determination of pKa of amino acid (glycine).

Biomolecules

1. Estimation of Protein using Lowry's method/Bradford method
2. Estimation of Glucose by DNS/ Phenol-sulphuric acid method
3. Estimation of Iodine number of fat/ oil
4. Determination of extinction coefficient of biomolecules using UV spectroscopy (Protein/DNA/RNA)
5. Estimation of cholesterol using CHOD-PAP/ kit method
6. Separation of biomolecules (amino acids/carbohydrates) using TLC.

TEXT BOOKS/ REFERENCES:

1. Lab Manual in Biochemistry, Immunology and Biotechnology by Arti Nigam and Archana Ayyagari. TATA McGraw Hill publishers, 1st edition,2008.
2. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan,1st edition, Springer 2011.
3. Principles and Techniques of Biochemistry and Molecular Biology, Keith Wilson & John Walker, 7th Edition, Cambridge University Press, 2018.
4. Biochemistry Laboratory: Practical Approach, Rodney F. Boyer, 2nd Edition, Pearson, 2017.
5. Vogel's Textbook of Quantitative Chemical Analysis 5th Edition (1989) A. I. Vogel, Longman, London, UK.
6. Principles of Instrumental Analysis 7th Edition (2014) Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Cengage Learning, Boston, USA.
7. Vogel's Quantitative Chemical Analysis 6th Edition (2000) J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, Pearson Education, London, UK.
8. Introductory Practical Biochemistry (2001) S. K. Sawhney, Randhir Singh, Narosa Publishing House, New Delhi, India.
9. An Introduction to Practical Biochemistry 3rd Edition (2004) D. T. Plummer, Tata McGraw Hill, New Delhi, India.
10. Principles and Techniques of Biochemistry and Molecular Biology 7th Edition (2010) Keith Wilson, John Walker, Cambridge University Press, Cambridge, UK.
11. Biochemical Methods 3rd Edition (2008) S. Sadasivam, A. Manickam, New Age International Publishers, New Delhi, India.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MBT5172**					
TITLE OF THE COURSE	**TECHNIQUES IN CELL & MOLECULAR BIOLOGY-PRACTICAL**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	-	**0**	**6**	**-**	**72**	**3**

COURSE OBJECTIVES:

- Introduce microscopy and basic staining techniques.
- Enable students to measure cell size and identify various blood cell types
- Provide hands-on experience in DNA and RNA extraction from plant or animal cells using simple extraction protocols
- Teach methods to quantify and assess DNA quality, and explain nucleic acid separation based on size, charge, and molecular weight and measure gene expression.

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will apply microscopy techniques to gain a clearer understanding of theoretical concepts and effectively correlate them with practical observations.	**L2**
CO2	Students will learn to accurately measure cell size and distinguish between different types of blood cells based on their morphological features.	**L3**
CO3	**Students will demonstrate proficiency in extracting DNA and RNA** from plant or animal cells using standard laboratory protocols.	**L3**
CO4	Students will be able to quantify and assess the quality of extracted DNA while understanding how nucleic acids are separated based on size, charge, and molecular weight besides gene expression analyses.	**L4**

LIST OF EXPERIMENTS

Cell Biology

1. Staining techniques- staining of blood cells and differential count.
2. H and E-stained slides for identification of different tissues.
3. Cell membrane permeability assay.
4. Study of haemorrhage using chick embryo.
5. Effects of drugs on mitosis (Eg: Colchicine Treatment)
6. Subcellular fractionation and isolation of organelle (Nucleus, Mitochondria)

Molecular Biology

1. Extraction of DNA from plant/bacterial cells.

2. Extraction of DNA from animal cells.
3. Extraction of RNA from given sample (plant/animal/microbe)
4. Separation and visualization of DNA/RNA on agarose gel electrophoresis.
5. Quantification of DNA/RNA by spectrophotometry.
6. PCR based detection of target gene
7. Quantifying Gene Expression- Fold Change Calculation from Ct Data

TEXT BOOKS/ REFERENCES:

1. Cell Biology: A Laboratory Handbook, Julio E. Celis (Editor), 2nd Edition, Academic Press, 1998.
2. Laboratory Exercises and Techniques in Cellular Biology, David M. Prescott, 1st Edition, Wiley, 2010.
3. Laboratory Methods in Cell Biology, P. Michael Conn (Editor), Volume 112, Academic Press, 2012.
4. Molecular Biology Techniques: A Classroom Laboratory Manual, Heather B. Miller, D. Scott Witherow, Sue Carson, 4th Edition, Academic Press, 2019.
5. Molecular Biology Techniques: An Intensive Laboratory Course, Walt Ream, Katharine G. Field, 1st Edition, Academic Press, 1998.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MBT5201**					
TITLE OF THE COURSE	**FUNDAMENTALS OF MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- **To familiarize students with fundamental concepts of microbiology, including microbial classification, physiology, and diversity.**
- **To prepare students for advanced studies in biological sciences by building a strong theoretical foundation in microbiology.**
- **To develop core laboratory skills such as microscopy, microbial culturing, and aseptic techniques for observing, identifying, and analysing microorganisms.**

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to describe the structural and functional characteristics of major microbial groups, and explain their significance in health, environmental processes, and industrial applications.	**L2**
CO2	Students will demonstrate proficiency in fundamental microbiological techniques, including microscopy, staining, culturing, and aseptic handling.	**L3**
CO3	Students will be able to determine microbial load in different samples.	**L4**

COURSE CONTENT:

MODULE 1: CLASSIFICATION AND DIVERSITY **14 Hrs**

Theory of Spontaneous generation. Prokaryotes, archaebacteria and eukaryotes. Classification of microbes - numerical and molecular taxonomy. Bergey's manual for identification of various microbes. Modern trends in nomenclature. Diversity of the microbial world. Important groups of prokaryotes – photosynthetic bacteria, blue green algae, chemoautotrophic bacteria, spore forming bacteria, mycoplasma. Overview of microbial genome.

MODULE 2: MICROBIAL NUTRITION AND ESSENTIAL TECHNIQUES **14 Hrs**

Microbial nutrition: Nutritional requirements for microbes and important nutritional groups. Function of different nutrients and their stress on microbes, mechanism of stress tolerance in microbes. Different types of media used for microbial culture (Complex media/Selective/Differential). Preparation of culture media, Sterilization and its types. Microscopy: Bright field, Dark field, Phase contrast, Differential interference contrast. Biosafety Cabinets (Class I, II and III), Laminar Flow Hoods, Autoclave, Oven, pH meter, Colony counter, Incubator-Shaker, Nephelometer.

MODULE 3: ISOLATION AND CHARACTERIZATION OF MICROBES	**14 Hrs**
Methods of isolation and purification (Serial dilution and types of plating), and preservation of microbes. Characterization of bacteria (Bergey's manual) and fungi (Lacto phenol Cotton Blue staining). Genetic characterization of microbes: rRNA based molecular identification, Whole genome sequence analyses.	
MODULE 4: QUALITY CONTROL AND MICROBIAL PRODUCTS	**14 Hrs**
Microbial growth curve. Effect of physical and chemical factors on microbes. Microbial growth estimation by direct and indirect methods: turbidity (O.D) and Colony forming Units (CFU) calculation. Environmental monitoring of microbes (water, surface, personnel, air, food), Indian Pharmacopoeia (IP) and US Pharmacopoeia (USP) standards- Sterility Test and Microbial Limit Test (MLT) for non -sterile products (pharmaceutical, healthcare and cosmetic products). Biopolymers from microbe (Xanthan gum), Enzymes from microbe, Nutraceuticals from Microbe, Biosurfactants.	
TEXT BOOKS/ REFERENCES:	

1. Prescott's Microbiology, Joanne M. Willey, Kathleen Sandman, Dorothy Wood, 12th edition, McGraw-Hill Education, 2022.
2. Bergey's Manual of Systematic Bacteriology, George M. Garrity, David R. Boone, Richard W. Castenholz, 2nd edition, Springer, 2012.
3. A Textbook of Microbiology, D.K. Maheshwari, 5th edition, S. Chand Publishing, 2022.
4. *Microbiology: An Introduction* , Tortora, G. J., Funke, B. R., Case, C. L., Bair, W. B., & Weber, D. 14th Edition, Pearson, 2023
5. Microbiology, OpenStax, 1st edition, OpenStax, 2016.
6. Textbook of Diagnostic Microbiology, Connie R. Mahon, Donald C. Lehman, 7th edition, Elsevier, 2022.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MBT5202**					
TITLE OF THE COURSE	**IMMUNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- Impart fundamental concepts of Immune system and its mechanism of action
- Instil basic understanding of MHC, TCR, antibodies, antigens, T cells, specific immune response; application of antibodies as reagents
- Instil principles of vaccines as disease preventive agents; principles of hypersensitivity and autoimmune disorders

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will develop a clear basic understanding of the fundamentals of mammalian immune system: cells organs and concepts	**L2**
CO2	Students will understand the nature of antigens, immunogenicity, antigenicity, antibody structure, isotypes and functions; Antigen antibody interaction; Clonal selection and expansion	**L3**
CO3	Students will be able to explain the immune response to hypersensitivity reactions and autoimmune disorders.	**L3**

COURSE CONTENT:

MODULE 1: INTRODUCTION AND BASIC CONCEPTS IN IMMUNOLOGY **14 hrs**

Introduction: Basic concepts in immunology. Cells and organs of immune system and their functions – Hematopoietic stem cell: myeloid and lymphoid progenitor cells. Primary and secondary lymphoid organs. Innate immunity: Different lines and layers of defence, secretions: skin, lysozyme, pH, mucous. Adaptive immunity and their characteristics. Pattern recognition in innate immune system (PRR, PAMP, DAMP, Signal Transduction Pathways Activated by PRR -TLR, Role of PRR in disease). Humoral and Cell mediated Immunity.

Note: Supplemented by research article.

MODULE 2: ANTIGEN ANTIBODY INTERACTIONS **14 hrs**

Antigens – types, epitopes, haptens, factors affecting immunogenicity, adjuvant concept; Antibodies – structure, isotypes, and functions of Immunoglobulins. Organisation of Antibody structure. Antigen-Antibody interaction, radio-equilibrium dialysis study. Complement system – components, functions, activation pathways (classical, alternative and lectin pathway). Basic outline or scheme of clonal selection in the humoral (B cell) and cellular (T cell) branches of immunity. Positive and negative selection of lymphocytes, Primary and secondary immune response- Immunological memory.

Note: Supplemented by research article.

MODULE 3: IMMUNE RESPONSES	**14 hrs**
Antigen presenting cells (APCs), Major Histocompatibility Complex (MHC) – MHC I and II. Interleukins and Interferons – brief introduction and their important functions. T cells subsets. Antigen processing and presentation- endogenous and exogenous antigen processing. Transplantation: Transplant rejection, immunosuppressants. Note: Supplemented by research article.	
MODULE 4: PATHO-IMMUNOLOGY & IMMUNOTECHNIQUES	**14 hrs**
Patho-immunology: Hypersensitive Reactions- Types and mechanism. Hypersensitive diseases. Autoimmune diseases- Rheumatoid arthritis, multiple sclerosis. Antibody production: Polyclonal and monoclonal. Immuno-techniques: Immuno-diffusion techniques, Flow cytometry. Quantitative ELISA and Qualitative ELISA. Immuno-florescence. Active & Passive immunization. Vaccines and its types. Note: Supplemented by research article.	
TEXT BOOKS/ REFERENCES:	

1. Janeway's Immunobiology, Kenneth Murphy, Casey Weaver, 9th Edition, Garland Science, 2016.
2. Kuby Immunology, Jenni Punt, Sharon Stranford, Patricia Jones, Judy Owen, 8th Edition, Macmillan Learning, 2018.
3. Roitt's Essential Immunology, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, 13th Edition, Wiley-Blackwell, 2017.
4. Immunology: A Short Course, Richard Coico, Geoffrey Sunshine, 8th Edition, Wiley-Blackwell, 2015
5. Abbas: Cellular and Molecular Immunology, Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai, 10th Edition, Elsevier, 2021.
6. The Immune System, Peter Parham, 5th edition, 2021.
7. Fundamental Immunology, William E. Paul (Ed.), 7th edition, 2012.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MBT5203**					
TITLE OF THE COURSE	**ENZYMOLOGY & BIOANALYTICAL TECHNIQUES**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To provide students with basic understanding of thermodynamics and their relevance in biological systems
- To provide students with a foundational knowledge of enzymology, focusing on its concepts and applications
- To familiarize students with the principles, concepts, and advanced applications of bio-analytical techniques used for detecting and assaying biomolecules

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will gain sufficient knowledge about basic concepts of thermodynamics and apply in biochemical reactions.	**L2 &L3**
CO2	Students will understand the role of enzymes, enzyme kinetics and basics of enzyme inhibition and the nature of their action.	**L3**
CO3	Students will be equipped with the basic concepts and principles of bioanalytical techniques and its applications in biotechnology	**L3 &L4**

COURSE CONTENT:

MODULE 1: THERMODYNAMICS	**14Hrs**

First & second laws of thermodynamics, enthalpy, entropy, Gibbs Free energy, Faraday's constant, Equilibrium constant. Chemical Kinetics: Rate of reaction- order& molecularity of reactions, Effect of temperature and pH on reaction rates, Arrhenius equation, Activated complex theory/transition state theory, Activation energy and catalysis

MODULE 2: ENZYMOLOGY	**14Hrs**

Introduction to enzymes, Microbial enzymes, Enzyme Classification -types of enzymes, enzyme Structure: Active site, cofactors, and coenzymes. Mechanism of enzyme action: lock and key model and induced fit hypothesis. Enzyme activity and Specific activity. Isozymes and their significance. Enzyme kinetics: Michaelis-Menten Kinetics: Vmax, Km, Lineweaver-Burk plot, and interpretation of kinetic data. Enzyme Inhibition: Competitive, non-competitive, uncompetitive inhibition; irreversible inhibition. Regulation of Enzymes: Feedback inhibition, covalent modification, Allosteric regulation. Mechanisms of Enzyme Catalysis. Screening for therapeutic candidates, Enzymes in diagnostics and therapeutics.

MODULE 3: ANALYTICAL TECHNIQUES FOR CHARACTERIZING BIOMOLECULES	**14Hrs**
Chromatography Techniques- Principle and applications (TLC, Affinity and Ion exchange, Gel filtration, GC, HPLC, FPLC,). Spectroscopic Techniques- principle and applications; UV-Vis - Absorption spectra of biomolecules (e.g., Carbohydrates, proteins, nucleic acids), Infrared Spectroscopy (IR): (Functional group analysis, secondary structure of proteins), Mass Spectrometry (MS), Fluorescence Spectroscopy (Principle and Applications).	
MODULE 4: GENETIC ANALYSIS AND IMAGING TECHNIQUES FOR BIOMOLECULES	**14Hrs**
Polymerase Chain Reaction (PCR), Agarose Gel Electrophoresis, Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (SDS-PAGE), Isoelectric Focusing, 2D-electrophoresis Western Blotting (Principle and applications). **Microscopic Techniques:** Light Microscopy, Fluorescence Microscopy, Electron Microscopy (SEM and TEM), Cryo-electron tomography, Atomic Force Microscopy (Principle and applications)	
TEXT BOOKS/ REFERENCES:	

1. Principles and Techniques of Biochemistry and Molecular Biology, Keith Wilson and John Walker, 8th Edition, Cambridge University Press, 2018.
2. Lehninger Principles of Biochemistry, DL Nelson, MM Cox, and AA Hoskins, 8th edition, W.H. Freeman & Company, 2021.
3. Principles of Biochemistry, Donald Voet, Judith G. Voet, and Charlotte W. Pratt, 5th edition, John Wiley & Sons, 2018.
4. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, Trevor Palmer and Philip L. Bonner, 2nd Edition, Woodhead Publishing, 2007.
5. Biotechnology, Satyanarayana U, 12th edition, Books and Allied Ltd, 2020.
6. Biophysical Chemistry: Principles and Techniques, A Upadhyay, K Upadhyay, and N Nath, 4th edition, Himalaya Publishing House, 2022.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MBT5204**					
TITLE OF THE COURSE	**GENETIC ENGINEERING FOR SYNTHETIC BIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To provide students with theoretical knowledge and practical skills in genetic engineering tools and vector systems
- To introduce gene editing technologies for the construction and analysis of synthetic biological systems
- To enable students to design synthetic gene circuits and pathways with applications in biotechnology
- To ensure students understand biosafety, ethics, and regulatory considerations in the development and application of synthetic biology

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to describe and apply core techniques in genetic engineering	**L2**
CO2	Students will evaluate and utilize vector systems for gene expression	**L3**
CO3	Students will discuss the ethical and biosafety concerns in synthetic biology applications	**L5**
CO4	Students will be able to Design and assemble synthetic circuits and operons	**L6**

COURSE CONTENT:

MODULE 1: TOOLS IN GENETIC ENGINEERING	**14 Hrs**

DNA structure and physicochemical properties, Enzymes used in genetic engineering: Restriction enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase, Recombinases and CRISPR-Cas systems for genome editing, Cohesive vs. blunt-end ligation, Linkers, adaptors, and homopolymeric tailing, DNA labeling techniques: Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Northern, Southern, and colony hybridization

MODULE 2: VECTORS AND EXPRESSION SYSTEMS	**14 Hrs**

Overview of cloning vector types and features: plasmids, phagemids, lambda vectors, cosmids, YACs, BACs, Representative vectors: pUC20, Bluescript, M13 mp vectors, Survey of special-purpose vectors: viral (SV40, retrovirus, baculovirus), plant-based (Ti and Ri plasmids), yeast and shuttle vectors, Expression vectors: pET, pGEX (GST-tag), pMal, His-tag vectors, Tags for protein purification: His-tag,

GST-tag, MBP-tag, Inclusion bodies and strategies to reduce their formation, Considerations in vector-host compatibility

MODULE 3: SYNTHETIC CIRCUITS, PATHWAYS AND TRANSFER TECHNOLOGIES	**14 Hrs**

Gene transfer methods: transformation, electroporation, transfection, microprojectile delivery, liposome-mediated transfer, Genomic and cDNA library construction and screening, Microarray construction: cDNA arrays, oligo array, Synthetic gene circuits and logic gates: toggle switch, repressilator, AND/OR/NOT gates, Synthetic operon and pathway construction, Metabolic engineering: design and optimization of metabolic pathways for enhanced production of biomolecules, Safety switches and kill-switch design, Assembly techniques: Golden Gate Assembly, Gibson Assembly, Techniques for DNA-protein interactions: EMSA, DNase I foot printing, methyl interference assay, ChIP, Protein-protein interactions: phage display, Surface Plasmon Resonance (SPR)

MODULE 4: ADVANCED TECHNIQUES AND APPLICATIONS	**14 Hrs**

DNA and RNA sequencing: enzymatic, chemical, automated, Next-generation sequencing technologies: Illumina, 454, SOLiD, PCR techniques: primer design, enzyme fidelity, multiplex, nested, RT-PCR, qPCR, site-directed mutagenesis, Mutation detection methods: SSCP, DGGE, RFLP, OLA, ASA, Directed evolution strategies, Applications of synthetic biology: healthcare, agriculture, bioenergy, Biosafety regulations and containment strategies, Ethical and social considerations in synthetic biology

TEXT BOOKS/ REFERENCES:

1. Gene Cloning and DNA Analysis: An Introduction, Brown, T. A., 6th Edition, Wiley-Blackwell, 2010.
2. Principles of Gene Manipulation and Genomics, Primrose, S. B., Twyman, R. M., 7th Edition, Wiley-Blackwell, 2006.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Glick, B. R., Pasternak, J. J., Patten, C. L., 4th Edition, ASM Press, 2010.
4. An Introduction to Genetic Engineering, Nicholl, D. S. T., 3rd Edition, Cambridge University Press, 2008.
5. Lehninger Principles of Biochemistry, Nelson, D. L., Cox, M. M., 7th Edition, W. H. Freeman, 2017.
6. Molecular Biology of the Cell, Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P., 6th Edition, Garland Science, 2014.
7. Molecular Cloning: A Laboratory Manual, Sambrook, J., Russell, D. W., 3rd Edition, Cold Spring Harbor Laboratory Press, 2001.
8. Foundations for Engineering Biology, Endy, D., Nature, 438, 449–453, 2005. (Journal article)
9. Online Resources: NCBI: https://www.ncbi.nlm.nih.gov. Registry of Standard Biological Parts: https://parts.igem.org

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MBT5205**					
TITLE OF THE COURSE	**FOOD AND ENVIRONMENTAL BIOTECHNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To comprehend basic concepts of food sciences their properties, and the factors affecting these properties.
- To equip the students with fundamentals of food processing and preservation and emerging concepts in food technology.
- To familiarize students with conventional and modern fuels and use of biotechnological methods in environmental quality, monitoring and remediation.
- To impart the knowledge on use of microorganisms in waste management and bio-recovery of metals.

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Student will be able to understand the basic concepts of food technology and comprehend different food standards for various categories of foods	**L2**
CO2	Students will be able to determine the fundamentals of food processing and preservation and emerging techniques in food processing	**L3**
CO3	Students will learn about fuels and use biotechnology methods to monitor environmental quality, and remediation of contaminated environments	**L3**
CO4	Students will be able to critically analyze the environmental issues and apply the biotechnology knowledge in resolving waste management and recovery of metals	**L3/L4**

COURSE CONTENT:

MODULE 1: INTRODUCTION TO FOOD TECHNOLOGY **14Hrs**

Basics of Food chemistry: Nutritional and compositional characteristics of major food groups (Carbohydrates, proteins, lipids, vitamins, minerals, water activity and its influence on shelf-life).

Food additives and Food adulterations: Food additives (preservatives, emulsifiers, stabilizers, colors, Flavors). Food adulterations- Common food adulterants and their health impacts. Standards of identity, purity, and safety, Food labelling laws and nutritional claims in Indian scenario. Analysis for food commodities: Moisture, protein, starch, oil content, contaminants, pH, microbial analysis

Food microbiology: Microorganisms in food- spoilage, pathogenic, and beneficial microbes, Fermented foods: microbial role in yogurt, cheese, sauerkraut, etc. Foodborne illnesses, control methods, and sanitation. HACCP, GMP, and hygiene regulations.

MODULE 2: FOOD PROCESSING AND PRESERVATION	14Hrs

Food processing: Definition, scope, and importance of food processing in global food security and nutrition. Techniques used in food processing - Primary, secondary, tertiary and advanced (Dairy, Nutraceuticals, and Plantation products).

Food preservation: Principles of food preservation: Thermal, cold, dehydration, Bio-preservation. Traditional methods and modern innovative methods (irradiation, MAP, hurdle technology). Food Quality control: Detection of food borne pathogens and toxins. Biosensors in food testing.

Biotechnology in Food Processing: Enzymes used in food processing (Chymosin- Cheese, Amylase-Bread, Pectinase- Juice), Recombinant enzymes in food industry (Snailase), GMO foods (Flavr Savr tomato, golden rice). Overview of Smart proteins- Cultivated meat, Plant based protein, Microbial based proteins-Single cell Protein, Mycoproteins (Source, Method of production, Applications and Challenges).

MODULE 3: BIOENERGY AND BIORECOVERY	14Hrs

Bioenergy: Conventional fuels (coal, firewood, gas), Modern biofuels and bioenergy solutions (Biogas production using methanogenic bacteria, Bioethanol production from sugar fermentation, Biodiesel),

Bio recovery: Biohydrometallurgy and Biomining -Bioleaching, biosorption, Enrichment of ores by microorganisms (Gold/Copper/Uranium).

MODULE 4: ENVIRONMENTAL WASTE MANAGEMENT AND POLLUTION CONTROL	14Hrs

Types and sources of waste: wastewater, solid waste, industrial and hazardous waste.

Waste water treatment: conventional wastewater treatment, Bioreactors for waste-water treatment, use of cell immobilization, use of algae. Microbial consortia for effluent detoxification.

Solid waste management- solid waste as renewable energy source, biotechnology applications in paper and pulp industry, Conversion of wood/agro-industrial waste to energy (biofuels/oils), anaerobic and aerobic composting, vermicomposting.

Bioremediation: Concepts and principles, Microbial bioremediation approaches (*in-situ* and *ex-situ),* Techniques used in bioremediation, biosorption and bioaccumulation (heavy metals), Phyto-remediation, Bioaugmentation.

Xenobiotics and their microbial degradation: Pesticides/herbicides/polyaromatic hydrocarbons/ microplastic/ nano-pollutants. Methods of pollution detection, Biosensors.

TEXT BOOKS/ REFERENCES:

1. Textbook of Environmental Biotechnology, P K Mohapatra, 1st edition, I.K. International Publishing House Pvt. Ltd, 2007.
2. Environmental Biotechnology: Basic Concepts and Applications, Indu Shekhar Thakur, 2nd edition, I.K. International Publishing House Pvt. Ltd, 2013.
3. Environmental Biotechnology: Concepts and Applications, Hans-Joachim Jördening and Josef Winter, 1st edition, Wiley-Blackwell, 2005.
4. Fundamentals of Food Biotechnology, Byong H. Lee, 2nd edition, John Wiley & Sons, 2015
5. Food Biotechnology, Kalidas Shetty, Gopinadhan Paliyath, Anthony Pometto, Robert E. Levin, 2nd Edition, CRC Press, 2005.

6. Food Biotechnology: Principles and Practices, Vinod Kumar Joshi, 1st Edition, I.K. International Publishing House, 2012.
7. Modern Food Microbiology, James M. Jay, Martin J. Loessner, David A. Golden, 8th Edition, Springer, 2005.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MBT5206**					
TITLE OF THE COURSE	**AI & ML FOR BIOLOGIST**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	**28**	**2**

COURSE OBJECTIVES:

- To understand and apply AI/ML techniques in biological research
- To analyse biological data using AI/ML tools
- To develop critical thinking and problem-solving skills

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Equip students with the foundational knowledge of artificial intelligence (AI) and machine learning (ML) algorithms and their application in various biological domains, including genomics, proteomics, drug discovery, and systems biology.	**L2**
CO2	Enable students to utilize AI/ML tools and frameworks to analyze complex biological datasets, such as gene expression data, protein interactions, and clinical data, and derive meaningful insights for hypothesis generation and validation in biological research.	**L2**
CO3	Foster critical thinking in the design and implementation of AI/ML models tailored to biological problems, focusing on the challenges of data quality, model interpretability, and ethical considerations in the biological sciences.	**L3**

COURSE CONTENT:

MODULE 1: INTRODUCTION TO AI & ML	**14 Hrs**

Introduction: Introduction to Artificial Intelligence, Definition of AI, AI Applications and Techniques. Machine Learning Fundamentals - Types of machine learning (supervised, unsupervised, reinforcement), algorithms, model evaluation, and bias-variance trade-off.
Mathematics for AI/ML: Linear algebra, probability, statistics, calculus - Data Structures and Algorithms: Understanding fundamental data structures and algorithms for efficient AI/ML development.
Applications of AI-ML in Biology: Drug Discovery and Development - AI and ML algorithms – in drug discovery - Genomics and Precision Medicine - ML models – Genome Data Analysis.

MODULE 2: MACHINE LEARNING ALGORITHMS & SPECIALIZED AREAS	**14 hrs**

Machine Learning Algorithms: Supervised Learning - Regression: Linear regression, logistic regression, polynomial regression - Classification: Support Vector Machines (SVM), Decision Trees, Random Forests, Naive Bayes - Unsupervised Learning: Clustering: K-Means, Hierarchical Clustering, DBSCAN.

Specialized Areas: Computer Vision: Image processing, object detection, image segmentation, CNNs - Robotics: Introduction to robotics, AI for robotics - Internet of Things (IoT): AI/ML applications in IoT - Knowledge Representation and Reasoning: Logic, knowledge bases - Data Analysis and Visualization: Tools and techniques for exploring and visualizing data.

Applications of ML Algorithms & Specialized Areas: Gene Expression Pattern Recognition - Classify diseases - cancer types - Identify biomarkers for diagnosis or treatment - Deep learning models - prediction of 3D structure of proteins – Understanding protein function.

TEXT BOOKS/ REFERENCES:

1. Bioinformatics: Sequence and Genome Analysis. David W. Mount. 2nd Edition. Cold Spring Harbor Laboratory Press, 2004.
2. Deep Learning for the Life Sciences. Bharath Ramsundar, Peter Eastman, and Patrick Walters and Vijay Pande. First Edition. O'Reilly Media, 2019.
3. Introduction to Machine Learning with Python. Andreas C. Müller and Sarah Guido, First Edition. O'Reilly Media, 2016.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MBT5271**					
TITLE OF THE COURSE	**INTEGRATED BIOANALYTICAL TECHNIQUES-PRACTICAL**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	-	**-**	**6**	**-**	**72**	**3**

COURSE OBJECTIVES:

- To introduce students to the principles of enzyme action and provide hands-on experience in isolating, purifying, and identifying enzymes using techniques such as precipitation, dialysis, chromatography, and SDS-PAGE.
- To equip students with practical skills in molecular biology tools and workflows—such as gene cloning, transformation, and expression analysis—while enabling them to design, assemble, and troubleshoot synthetic gene circuits for real-world applications.
- To understand and apply immunological techniques commonly used as diagnostic tools, and real-world applications in disease detection and research

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to demonstrate practical skills in the isolation, purification, and identification of enzymes using numerous techniques.	**L3/L4**
CO2	Students will perform gene cloning, transformation, and expression analysis, and effectively design, assemble, and troubleshoot synthetic gene circuits.	**L3/L4**
CO3	Students will acquire practical knowledge of immunological techniques commonly used as diagnostic tools	**L2/L3**

LIST OF EXPERIMENTS

Enzymology

1. Isolation of enzyme and estimation of its activity (Urease/Acid Phosphatase/esterase) - any one
2. Determine the specific activity of enzyme using a Std BSA curve.
3. Determination of kinetic properties enzyme (Km and Vmax).
4. Partial purification of the enzyme by salting out/acetone and dialysis.
5. To perform SDS-PAGE and check the purity of the isolated enzyme.
6. Demonstration of chromatographic technique for purification of enzyme (Gel filtration/Ion exchange)
7. To evaluate the sensitivity of enzyme against any one standard inhibitor (IC50 Determination)

Genetic engineering

1. Cloning (Primer Designing, Competent cell preparation, Plasmid Isolation and Restriction Digest Analysis, Ligation)

2. Transformation, Protein expression and Confirmation
3. Site-Directed Mutagenesis and Screening

Immunology

1. Serum separation and Quantification of Serum Proteins
2. ELISA for Antigen Detection (e.g., model allergen or bacterial antigen)
3. Radial Immunodiffusion/Ouchterlony Double Diffusion
4. Immunoelectrophoresis

TEXT BOOKS/ REFERENCES:

1. Laboratory Methods in Enzymology-Part A, Jon Lorsch, 1st edition, Academic Press (Elsevier Science), 2014.
2. Molecular Therapeutics: 21st Century Medicine, Pamela Greenwell and Michelle McCulley, 1st edition, Springer, 2008.
3. Roitt's Essential Immunology, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, and Ivan M. Roitt, 13th edition, Blackwell Scientific Publishers, 2017.
4. Principles of Gene Manipulation and Genomics, S. B. Primrose and R. M. Twyman, 8th edition, Wiley-Blackwell, 2022.
5. Biochemical Methods, S. Sadasivam and A. Manickam, 4th edition, New Age International, 2022.
6. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Bernard R. Glick, Jack J. Pasternak, and Cheryl L. Patten, 6th edition, ASM Press, 2022.
7. Essential Immunology, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M.Roitt, 12th edition, ELBS, Blackwell Scientific Publishers, London, 2011.
8. Janeway's Immunobiology, Kenneth Murphy, Paul Travers, Mark Walport, 9th edition, Garland Science, 2016.
9. Essential Clinical Immunology**,** John B. Zabriskie, Cambridge University Press, 2009.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MBT5272**					
TITLE OF THE COURSE	**TECHNIQUES IN MICROBIOLOGY AND SUSTAINABLE BIOTECHNOLOGY- PRACTICAL**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar /Projects Hours	Total Hours	Credits
	-	**0**	**6**	**-**	**72**	**3**

COURSE OBJECTIVES:

- To familiarize students with determining water quality and develop techniques for management of waste/pollutants.
- To provide a comprehensive understanding of methods for detection of adulterants/ components in food.
- To familiarize students with essential microbiological techniques and provide hands-on experience in methods used in both basic and applied microbiology.

COURSE OUTCOMES:

Co No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to perform the experiments to assess the quality of the water, and to isolate the xenobiotic degrading bacteria.	**L3/L4**
CO2	Students will have an understanding for detection of food components and adulterants.	**L3/L4**
CO3	Students will be able to perform core microbiological techniques and apply them to both basic and applied microbiology.	**L2/L3**

LIST OF EXPERIMENTS

Microbiology

1. Preparation of culture media: Selective, Enriched and Differential.
2. Isolation of Microorganisms from different sources (Soil, water and air): Serial dilution and Pure culture techniques.
3. Staining- simple, differential - Gram's, endospore, capsular and flagella.
4. Microscopic Examination of fungi
5. Determination of Bacterial Growth Curve -Study growth phases of bacteria (lag, log, stationary, death).
6. 16S rRNA sequence analysis for bacterial identification (*E. coli /S. aureus*).
7. Life cycle assessment of microbes

Environmental Biotechnology

1. Calculation of BOD and COD of sewage water sample.
2. Detection of coliforms for determination of the purity of potable water by MPN Method.
3. Isolation of xenobiotic degrading bacteria by selective enrichment techniques.
4. Determination of sulphates in the water by turbidometric method.

Food Biotechnology

1. Determination of adulterant (starch) in milk using iodine
2. Determination of total protein content in milk.
3. Detection of antioxidants in food (fruit/vegetable)
4. Detection of polyphenols in food (fruit/vegetable)
5. Estimation of moisture content, total ash and acid insoluble ash

TEXT BOOKS/ REFERENCES:

1. Handbook of Analysis and Quality Control for Fruit and Vegetable Products, S. Ranganna, 2nd Edition, McGraw Hill Education, 2017.
2. Laboratory Manual in Food Microbiology, K.R. Aneja, 2nd Edition, Medtech Publishers,2018.
3. *Food Science*, B. Srilakshmi, 9th Edition, New Age International (P) Limited, Publishers, 2024.
4. Practical guide to environmental biotechnology, Jayanta Kumar Patra, Gitishree Das, Swagat Kumar Das, Hrudayanath Thatoi, 1st Edition, Springer Nature Singapore, 2020.
5. Experiments in Microbiology, Plant Pathology and Biotechnology, K.R. Aneja, 6th Edition, New Age International (P) Ltd., 2023.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MBT5301**					
TITLE OF THE COURSE	**INDUSTRIAL BIOTECHNOLOGY**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To impart basic understanding of principles and key concepts relevant to industrial Biotechnology.
- To describe the design aspects of bioreactor including the upstream and downstream processing.
- To apply the biotechnological concept in the production of biologicals.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	To help students achieve knowledge in principles and concepts relevant to industrial biotechnology.	L1
CO2	Students will be updated with the current methods of fermentation process and modern fermenters.	L2
CO3	To familiarize the students with upstream and downstream processing, types of fermenters and production of important microbial products.	L2
CO4	Student will be able to apply the knowledge in their future with respect to industrial biotechnology processes.	L3

COURSE CONTENT:

MODULE 1: MICROBIAL GROWTH, DEVELOPMENT AND STRAIN IMPROVEMENT	**14Hrs**

Microbial growth and death kinetics (particularly with reference to industrially useful microorganisms). Isolation, Screening, morphological, immunological and molecular identification of industrially important microbes. Culture collection centres.

Strain improvement- mutation, selection and recombination- gene regulation and genetic manipulation, test for gene stability. Case studies in strain improvement for production of amino acids and anti-biotics.

MODULE 2: BIOREACTORS AND FERMENTATION	**14Hrs**

Basic instrumental components of a bioreactor; Introduction to Chemostat and Turbidostat. bioreactor configurations- components - types of bioreactors, modes of operation of bioreactors – continuous stirred tank reactor, batch reactor, fed batch reactor, stirred tank reactor with recycle and reactors in series; reactors for plant cells and animal cells, immobilized reactors. Submerged and Solid-state fermentation. Cleaning (CIP) and sterilization of bioreactors (ESIP) and fermenters (FSIP)

Monitoring of Bioprocess: Introduction to Open loop and Closed loop control mechanisms. Process variable measurement and control – temperature, gas and liquid flow, pressure, agitator, pH, biomass, foam formation, weight, dissolved oxygen, inlet and exhaust gas, redox and carbon dioxide; probes for sampling and control; sensors; on-line data analysis for measurement of parameters; basics of computer application in bioprocess- Introduction to HMI, PLC.

MODULE 3: UPSTREAM PROCESSING AND DOWNSTREAM PROCESSING	**14Hrs**

Formulation of fermentation media.

Rheology of fermentation media. Nutrients: growth factors, carbon, nitrogen, energy and mineral sources, buffers, inhibitors, precursors, inducers, oxygen requirements, antifoam agents and others. Methods of sterilization (FSIP), inoculum preparation. Inoculum development: RCB- MCB- WCB.

Downstream processing: Steps in recovery and purification of fermented products. Solid matter, Foam separation, Precipitation, Depth Filtration, Centrifugation, Cell disruption, Liquid- Liquid extraction, Solvent recovery, Supercritical fluid extraction, chromatography, Membrane processes. Introduction to virus reduction steps – methods- Low pH holding- Ion exchange chromatography- nano filtration

Drying, Crystallization, Whole broth processing, Effluent treatment.

MODULE 4: APPLIED INDUSTRIAL BIOTECHNOLOGY	**14Hrs**

Industrial production of small molecules: Organic acids (citric acid), Amino acid (L Glutamic acid and L-lysine), antibiotic (Penicillin and Streptomycin). Macro molecules: biopolymers (dextran, alginate). Industrial production of Enzymes: Production Fungal and Bacterial Amylase. Health care bioproduct: Vaccines (Hepatitis B) and hormones (human insulin). Industrial alcohol production, Beverages. (Biosimilars: Manufacturing of Biosimilars, Regulatory guidelines, Case Study- Production Process of Biosimilar Insulin Analogs, Diabetes management, Monoclonal Antibody Biosimilars (Trastuzumab)-Cancer therapeutics, Ozempic-diabetics therapeutics.

TEXT BOOKS/REFERENCES:

1. Bioprocess Engineering in Biotechnology, Jackson A. T., 1st edition, Prentice Hall (Englewood Cliffs), 1991.

2. Bioprocess Engineering: Basic Concepts, Shuler M. L. and Kargi F., 2nd edition, Prentice Hall (EnglewoodCliffs),2002.

3.Principles of Fermentation Technology, Stanbury P. F., Whitaker A., and Hall S. J., 3rd edition, Butterworth-Heinemann(Elsevier),2016.

4.*F*ermentation Microbiology and Biotechnology, Mansi E. M. T. E. L. and Bryle C. F. A., 2nd

edition,Taylor & Francis Ltd (UK), 2007.
5.Basic Biotechnology, Ratledge C. and Kristiansen B., 2nd edition, Cambridge University Press, 2002.
6.Prescott & Dunn's Industrial Microbiology, Gerald Reed (Editor), 4th edition, CBS Publishers & Distributors Pvt Ltd (India), 2004.
7. Bioprocess Engineering*: Basic Concepts*, Shuler M. L. and Kargi F., 2nd edition, Prentice Hall (Englewood Cliffs), 2001.
8.Bioprocess Engineering Principles, Doran P. M., 1st edition, John Wiley & Sons, 2003.
9. Bioprocessing Technology for Production of Biopharmaceuticals and Bioproducts, Claire Komives and Weichang Zhou, 1st edition, Wiley, 2018.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MBT5302**					
TITLE OF THE COURSE	**PLANT AND AGRICULTURE BIOTECHNOLOGY**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- Introduce foundational concepts in plant biology, genetics, and molecular biology relevant to biotechnological applications.
- Explore key techniques such as genetic engineering, tissue culture, molecular markers, and genome editing used in crop improvement.
- Examine the role of biotechnology in enhancing crop yield, disease resistance, stress tolerance, and nutritional value.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Explain fundamental concepts of plant biology and biotechnology, including molecular genetics, plant physiology, and cellular processes relevant to agricultural applications.	**L2**
CO2	Demonstrate knowledge of modern biotechnological tools and techniques such as plant tissue culture, genetic transformation, molecular markers, and genome editing.	**L3**
CO3	Analyse the genetic and biochemical basis of traits such as drought resistance, pest tolerance, and nutritional enhancement in crops.	**L4**
CO4	Apply biotechnology methods to address real-world problems in agriculture, such as crop improvement, sustainable farming, and food security.	**L3**

COURSE CONTENT:

MODULE 1: CROP ENHANCEMENT AND MOLECULAR BREEDING	**14Hrs**

Overview of crop improvement, Role of molecular breeding in global food security. Molecular breeding Techniques: Marker-Assisted Selection (MAS), Marker-Assisted Backcrossing (MABC), QTL mapping, Genomic Selection (GS).

Genetic Engineering and transgenic crops: Gene transfer methods (Agrobacterium mediated, direct methods), Ti and Ri plasmids, vectors (cointegrate, binary, viral), Selectable and screenable markers. Case studies (e.g., Glycine max for herbicide resistance, DREB1A gene in rice).

MODULE 2: PRECISION GENOME EDITING AND TRANSGENIC HYBRID PRODUCTION	**14HRS**
Seed genetics and trait development; Seed Genetics, Key Methods of Trait Development; Conventional Breeding, Genetic Engineering (GMOs); Transgenic Modification Bt crops (e.g., Bt corn), Gene Editing; CRISPR/Cas9 (Editing wheat genes to improve drought tolerance or reduce gluten content), TALENs (production of high-oleic soybean), and ZFNs for precise genome modifications (herbicide tolerance Zea mays production). GM Strategies for Biotic and Abiotic Stress Resistance/Tolerance, Herbicide, bacterial and fungal resistance crops; Concept of bio factories; Production of pharmaceutical proteins Plantibodies, vaccines and industrial enzymes in plants. Metabolic engineering for oil improvement. Biosafety and regulatory aspects including IPR.	
MODULE 3: MICROPROPAGATION AND TISSUE CULTURE FOR CROP PRODUCTION	**14HRS**
Scope and Importance of plant tissue culture; Totipotency; Media composition and types (Murashige and Skoog, B5, White's Medium, Nitsch (NN) Medium), hormones and growth regulators. pH of tissue culture media. Adjuvants in plant culture media. Sterilization of nutrient media and explants; Organogenesis; Mass propagation (Micropropagation); Meristem Culture for disease free plant, Somatic embryogenesis and its applications; Somaclonal variation; Anther and embryo culture for haploid production and its applications in plant breeding; protoplast isolation; culture and usage; somatic hybridization-methods and applications; synthetic seed preparation, Cybrids. Cell suspension cultures and Callus Culture for Secondary Metabolite Production.	
MODULE 4: SUSTAINABLE AGRI-BIOTECHNOLOGY	**14HRS**
Biofertilizers: Microbial inoculants (e.g., bacteria, fungi, algae). Types of Biofertilizers; Nitrogen-fixing biofertilizers (Rhizobium, Azospirillum and Azotobacter), Phosphate-solubilizing microorganisms (Bacillus subtilis, Aspergillus niger), Potassium-mobilizing microbes (Frateuria aurantia), Mycorrhizal fungi (Arbuscular mycorrhizal fungi), Production of biofertilizers. Biopesticides: Natural agents as biopesticide (microbial, biochemicals) *Bacillus thuringiensis* (Bt) for insect control, Trichoderma for fungal pathogens. Biochemical pesticides; Neem oil (azadirachtin), pyrethrum from chrysanthemum, Plant-incorporated protectants; Bt toxin genes in transgenic crops (e.g., Bt cotton and Bt brinjal).	
TEXT BOOKS/ REFERENCES:	
1. Introduction to Plant Biotechnology, HS Chawla, 3rd Edition, Oxford and Ibh Publishing, 2020. 2. Drought stress tolerance in transgenic wheat conferred by expression of a dehydration-responsive element-binding 1A gene, Mehmood, K., Arshad, M., Ali, G. M., Shah, S. H., Zia, M. A., Qureshi, A. A., & Qureshi, R. Plant Biotechnology Journal, 2 019. 3. CRISPR-mediated acceleration of wheat improvement: advances and perspectives, Ximeng Zhou, Yidi Zhao, Pei Ni, Zhongfu Ni, Qixin Sun, Yuan Zong, Journal of Genetics and Genomics, 2023. 4. Plant Biotechnology – genetic manipulation of plants, Slater, 2nd Edition, Oxford Publishing, 2008.	

5. Biotechnology : Expanding Horizons, B D Singh, 5th Edition, Kalyani Publishers, 2023.
6. Introduction to Plant Cell, Tissue and Organ Culture. SD Purohit. Hall India Learning Pvt Ltd, 2012.
7. Genetic Engineering of Crop Plants, Lyrett G W and Grierson D, Butterworths publishers, 1990.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MBT5303**					
TITLE OF THE COURSE	**ANIMAL BIOTECHNOLOGY AND REGENERATIVE MEDICINE**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

- To provide in-depth knowledge of the principles and applications of animal biotechnology & regenerative medicine.
- To introduce students to stem cell biology, tissue engineering & regenerative medicine strategies.
- To expose students to ethical and regulatory considerations in animal and regenerative research.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the basics of animal biotechnology, cell culture techniques and their applications.	L2
CO2	Understand how engineered tissues are developed and applied in regenerative therapies.	L3
CO3	Understand the fundamentals of stem cell biology and its translational potential in regenerative medicine.	L4

COURSE CONTENT:

MODULE 1: ANIMAL CELL CULTURE AND TRANSGENIC TECHNOLOGIES	**14Hrs**

Basics of animal cell culture techniques: Introduction, Laboratory design and key equipment, Growth media and supplements, cell growth kinetics and viability assays, Cell Types and Culture methods: Primary cell culture technique (explant, mechanical, enzymatic), Secondary cell culture (Finite and continuous cell lines), Example: CHO -Chinese Hamster Ovary (normal), HeLa (cancerous). Cell banking and biosafety. Introduction to Transgenesis, Principal methods for production of transgenic animals (DNA microinjection, embryonic stem cell-mediated gene transfer and retrovirus-mediated gene transfer), Gene knockout techniques: Homologous recombination (SMAΔ7 Mouse Model for spinal muscular atrophy), CRISPR/Cas9-Mediated knockout (*P53* Gene knockout in mice for cancer research), TALENs. Transgenic Animal Models in Disease Research: Transgenic mice models, Mouse xenograft models, IVF technology.

MODULE 2: STEM CELLS AND TISSUE ENGINEERING IN REGENERATIVE MEDICINE	**14Hrs**

Stem cell types – Adult, Embryonic, Induced pluripotent stem cells. Isolation of adult stem cells, Stem cell markers and characterization (Flow cytometry-based analyses of surface markers and Expression profiling of stem cell related genes), Stem cell differentiation and lineage commitment. Case study: iPSC-derived retinal cells using skin cells for treating macular degeneration.

Introduction to Tissue Engineering, Importance of Scaffolds, Types of scaffold materials: Natural and Synthetic biomaterials, Smart Biomaterials (pH sensitive, thermo-responsive), Scaffold fabrication techniques: Solvent casting and Particulate leaching, Electrospinning, 3D- bioprinting and organoid development, Application of tissue engineering (Skin regeneration, Bone repair, Liver repair, Cartilage repair) Organoid models in disease modelling and drug screening. Regulatory and commercialization aspects. Advances in bio-printing and synthetic biology - Future prospects and global scenario.

MODULE 3: INDUSTRIAL APPLICATIONS	**14Hrs**

Manufacturing of pharmaceutical proteins using mammalian cells, Monoclonal antibody, hormone, enzyme, development of cell-based therapies (cartilage repair, retinal cells), Bioengineered skin grafts (Product-Apligraf), Gene Therapy trials using Animal Models, Livestock for production of vaccine/ antibody (horses), pharming products (Pharmaceutical Proteins in Milk). Livestock improvement and Disease control: Genome editing (Porcine Reproductive and Respiratory Syndrome resistant pigs via CD163 gene editing) and RNAi (Avian influenza-resistant chickens). Other applications: Transgenic insects for Pest Control, Transgenic fish for Bioremediation.

TEXT BOOKS/ REFERENCES:

1. Animal Cell Culture. R. Ian Freshney. 7th Edition. Wiley-Blackwell, 2015.
2. Principles of Tissue Engineering. Robert Lanza, Robert Langer, and Joseph Vacanti. 4th Edition. Academic Press, 2013.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA. Glick, T. L. Pasternak. 4th Edition. ASM Press, 2010.
4. Stem Cells: Scientific Facts and Fiction. Christine Mummery, J.C. van der Vleuten, et al. First Edition. Garland Science, 2004.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MBT5304**					
TITLE OF THE COURSE	**MEDICAL BIOTECHNOLOGY**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

- To provide knowledge on the cause and molecular mechanism of human diseases.
- To equip students with technologies/techniques that targets/uses biomolecules (nucleic acids and proteins) for a specific disease diagnosis.
- To equip students with technologies/techniques that uses biomolecules (nucleic acids and proteins) and cells as therapeutics for a specific disease treatment.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to illustrate the cause and molecular basis of different diseases.	L1
CO2	Students will be able to explain different techniques that use biomolecules (DNA, RNA, protein) for disease diagnosis.	L2
CO3	Students will be able to describe wide range of therapeutic strategies	L2
CO4	Students will be able to demonstrate skills to diagnose diseases by molecular methods.	L3

COURSE CONTENT:

MODULE 1: DISEASES- MOLECULAR MECHANISM	**14Hrs**

Infectious disease (Bacterial Infection- Tuberculosis, Salmonellosis, Viral infection – Hepatitis, Corona, Dengue, Parasitic disease- Amoebiosis and Malaria): Genetic characteristics of causative agent, host-pathogen interaction, symptoms. Metabolic disease (Example: Diabetes), Genetic disorders (Example: Sickle Cell anaemia); Driver genes of Cancer, Antimicrobial resistance (AMR).

MODULE 2: MOLECULAR DIAGNOSTICS	**14Hrs**

Immunological approaches (ELISA to detect HIV, Dengue), DNA based approaches (PCR/Real Time PCR/Next generation sequencing to detect HIV, *Salmonella typhimurium*), RNA signatures of diseases (changes in gene expression using transcriptome analyse- Cancer). Miniature point of care devices: Biochips i.e., Lab-on-a-Chip (VereChip for simultaneous detection of multiple markers, OncoChip™ for

detection of BRCA1 and BRCA2 mutations in breast cancer), Biosensors based real time detection of molecular interactions (Pathogen detection) using suitable transducers (electrochemical, optical).

MODULE 3: MOLECULAR THERAPEUTICS & VACCINE PRODUCTION	**14Hrs**

Biologics, Biosimilar and Biobetters. Protein therapeutics: Pharmaceutical (Insulin), Recombinant Antibodies (Monoclonal antibodies), Enzymes [Glucocerebrosidase (GCase) for Gaucher disease]. Nucleic acid therapeutics: Targeting specific mRNA and DNA (Antisense RNA, Aptamers), Gene Therapy: Gene delivery systems as viral [adenoviral, herpes simplex virus], nonviral delivery systems (physical: DNA bombardment, electroporation) and (chemical: Cationic lipids, cationic polymers). In vivo and Ex-vivo delivery (Cytokine IL-12 in cancer). Genome Editing: (CRISPR Cas9 system for genetic disorder). Advanced Immunotherapy: Chimeric Antigen receptor (CAR-T) cell therapy.

Vaccine: DNA, RNA, and Recombinant Protein Strategies. Case study: Hepatitis B recombinant subunit vaccine (HBsAg protein expressed in yeast or mammalian cells) -Engerix-B/ Recombivax HB.

TEXT BOOKS/ REFERENCES:

1. Medical Biotechnology, Gernard R. Glick, Terry L Delovitch, Cherry L. Pattern,1st Edition, ASM Press (American Society for Microbiology), 2013.
2. Medical Biotechnology, Judit Pongracz and Mary Keen, 1st Edition, Elsevier publications, 2008.
3. Rajneesh Prajapat, M. Kasturi, B. Manivannan, Anita Mishra, Fundamentals of Medical Biotechnology.
4. Molecular Medicine: An Introductory Text, Ronald J. Trent, 3rd edition, Elsevier Academic Press, 2005.
5. Principles and Applications of Molecular Diagnostics, Nader Rifai, A. Rita Horvath, Carl T. Wittwer, Jason Park, 1st edition, Elsevier, 2018.
6. Molecular Diagnostics: Promises and Possibilities, Mousumi Debnath, Godavarthi B.K.S. Prasad, Prakash S. Bisen, Springer, 2010.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MBT5305**					
TITLE OF THE COURSE	**SYSTEM BIOLOGY & DRUG DISCOVERY**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

- To understand the systems-level organization of biological processes relevant to drug discovery.
- To learn modelling and simulation techniques to analyse biological networks.
- To explore omics data integration and its use in identifying drug targets.
- To apply systems-based approaches to predict drug response and optimize therapeutic strategies.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will describe systems biology principles and biological networks.	L2
CO2	Students will be able to apply modelling approaches to simulate biological systems	L3
CO3	Students will be able to integrate case studies to interpret therapeutic applications.	L4
CO4	Students will be able to evaluate drug response using systems pharmacology tools.	L5

COURSE CONTENT:

MODULE 1: INTRODUCTION TO SYSTEMS BIOLOGY AND NETWORK BIOLOGY	**14Hrs**

Overview of systems biology: Definitions, applications, and scope, Concepts of robustness, emergence, and modularity, Types of biological networks: gene regulatory, metabolic, PPI networks, Graph theory basics for biological networks, Network properties: degree distribution, hubs, motifs, clustering, Tools: Cytoscape, STRING.

MODULE 2: MODELLING AND SIMULATION OF BIOLOGICAL SYSTEMS	**14Hrs**

ODE-based and stochastic modelling, Boolean and logic-based modelling approaches, Dynamic behaviour of biological systems: feedback, bistability, oscillations, Model validation and parameter estimation, Software tools: COPASI, CellDesigner, Case study: modelling a metabolic pathway or signalling cascade

MODULE 3: SYSTEMS PHARMACOLOGY AND DRUG DISCOVERY APPLICATIONS	**14Hrs**
Omics Integration and Drug Target Discovery: Introduction to transcriptomics, proteomics, and metabolomics, Multi-omics data integration strategies, Identifying key pathways and targets using omics data, Pathway and enrichment analysis (DAVID, KEGG, Reactome), Network-based target prioritization, Case study: Network-based repurposing for antimicrobial or cancer therapy. Principles of systems pharmacology and polypharmacology, Drug-disease network analysis and prediction of drug response, Simulation of drug action and resistance mechanisms, In silico strategies for drug repurposing, Personalized medicine and virtual patient models, Tools: DrugBank, LINCS.	

TEXT BOOKS/ REFERENCES:

1. Systems Biology: A Textbook, Klipp, E., Liebermeister, W., Wierling, C., et al., 2nd Edition, Wiley-VCH, 2016.
2. Systems Biology: Mathematical Modeling and Model Analysis, Kremling, A., 1st Edition, CRC Press, 2013.
3. Systems Biology: Constraint-Based Reconstruction and Analysis, Palsson, B., 1st Edition, Cambridge University Press, 2015.
4. Computational Systems Biology, Kriete, A., Eils, R. (Eds.), 1st Edition, Academic Press, 2006.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MSC5301**					
TITLE OF THE COURSE	**RESEARCH METHODOLOGY, SCIENTIFIC WRITING AND IPR**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

- Students will gain a comprehensive understanding of how to design and conduct research ethically and systematically.
- The course will develop students' ability to communicate research findings effectively through structured and impactful scientific writing.
- Students will learn the fundamentals of innovation protection, including the legal aspects of intellectual property and how to safeguard their work.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to understand and apply principles of research design and methodology.	L3
CO2	Design and evaluate research methodologies, including data analysis and ethical considerations	L5
CO3	Students will be able to understand various forms of intellectual property and their legal significance apply ethical principles in research and publication.	L2

COURSE CONTENT:

MODULE I- RESEARCH METHODOLOGY **14Hrs**

Objectives of research. Types of research. Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical. Research process. Criteria of good research. Developing a research plan. Defining the research problem. Techniques involved in defining the problem Survey of literature. Methods of data collection. Primary and secondary sources. Identifying gap areas from literature review. Development of working hypothesis. Testing of hypotheses.

Research design and methods. Features of good design. Time frame. Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan. Exploration, Description, Diagnosis, and Experimentation. Determining experimental and sample designs. Sampling – Steps, size determination and types. Good Laboratory Practices (GLP) and ethics- GLP Principles and SOP documentation.

MODULE II – SCIENTIFIC WRITING	**14Hrs**
Introduction to Scientific Writing- common types (articles, reports, reviews, thesis), Sources of scientific literature (PubMed, Scopus, Web of Science, Google Scholar). Structure of a Scientific Paper and Thesis, Literature Review and Referencing, Citation styles- APA and MLA styles of citation. Contents: Abstract, keywords, introduction, results, discussion, conclusion, Figures and Tables. Data Presentation- Effective visuals, legends, formatting, posters and oral presentations. Communication skills and handling Q&A. Writing Research Proposals. Components of a research proposal. Budgeting and timelines. Tips for writing successful grant applications. Review and Publishing Process. Types of scientific journals and peer review process. Choosing a journal for submission. Dealing with reviewers' comments and revisions. Ethics in Scientific Writing- Plagiarism, authorship, data manipulation, conflict of interest, Peer Review and Publication Process- How to submit a paper, respond to reviewers, predatory journals.	
MODULE III- INTELLECTUAL PROPERTY RIGHTS AND PATENTS	**14Hrs**
Introduction to Intellectual Property, Types of IPR (patents, copyrights, trademarks, trade secrets), Patents in Biological sciences - Patentability criteria, examples of Life science patents, Indian Patent Act, international treaties (TRIPS, WIPO), Pros and Cons of IP protection. Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments. Patent Filing and Process- Steps of filing a patent (India and abroad), patent databases and search tools (e.g., WIPO, Espacenet). Prior art search. Types of patent applications. Licensing, IP management, technology transfer and commercialization, role of incubation centres and research institutions, Ethical and Legal Issues- Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner. Agreements and Treaties: GATT, TRIPS Agreements; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions.	
TEXT BOOKS/ REFERENCES:	
1. An introduction to Research Methodology, Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 1st edition, RBSA Publishers, 2002. 2. Research Methodology: Methods and Techniques, Kothari, C.R. and Garg, G., 4th ed. New Age International Publishers. 2019. 3. Research Methodology for Biological Sciences, Gurumani, N., 2nd edition, MJP Publishers, 2016. 4. Scientific Writing and Communication: Papers, Proposals, and Presentations, Hofmann, A.H., 2nd edition, Oxford University Press. 2016. 5. How to Write and Publish a Scientific Paper, Gastel, B. and Day, R.A., 9th edition, Cambridge University Press, 2022. 6. The Craft of Scientific Writing, Alley, M., 4th edition, Springer, 2018. 7. An Introduction to Intellectual Property Rights, Mishra, J.P., Central Law Publications, 2012.	

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MBT5306**					
TITLE OF THE COURSE	**NANOBIOTECHNOLOGY**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	**28**	**2**

COURSE OBJECTIVES:

- Introduce fundamental concepts of nanoscience and nanotechnology relevant to biological systems.
- Explore the interactions between nanomaterials and biological entities, including proteins, DNA, cells, and tissues.
- Understand the synthesis and characterization of nanostructures such as nanoparticles, nanotubes, and nanocomposites for biomedical and agricultural applications.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Should be able to understand the different types and characterization of nanomaterials.	**L2**
CO2	Should be able to analyze the applications of nanomaterials in biotechnology.	**L3**
CO3	Should be able to apply nanobiotechnology in health and agriculture.	**L4**

COURSE CONTENT:

MODULE 1: INTRODUCTION, SYNTHESIS AND CHARACTERIZATION OF NANOMATERIALS	**14Hrs**

Introduction to nanomaterials, Types of Nanomaterials**:** Organic (liposomes, polymeric nanoparticles, dendrimers), Inorganic (Metal NPs-Silver, Gold; Magnetic NPs, Semiconductor NPs- Quantum dots), Carbon-based (Carbon nano tubes, graphene, carbon dots, carbon nanofiber), Hybrid nanomaterials, Properties of nanomaterials.

Methods for nanoparticle synthesis: Top down and bottom-up approaches-Physical methods (Electron beam lithography), Chemical method, biological method – green synthesis (plant, microbes).

Characterization Techniques**:** Size and morphology (TEM, SEM, AFM), Composition: XRD, FTIR, Surface charge: Zeta potential.

MODULE 2: APPLICATIONS OF NANOMATERIALS	**14Hrs**

Medical applications: Drug Delivery- Polymeric nanoparticle formulation of drug PACLITAXEL used for cancer, Vaccine Delivery (Lipid nanoparticles in mRNA vaccines), Diagnostics & Biosensing - Quantum dots-based detection of cancer biomarker, Lateral flow assay using gold nanoparticle.
Theranostic: Dual-purpose agents for imaging and therapy (Quantum Dots and siRNA for gene delivery and imaging), Nano sensors for health monitoring, environmental safety and biomedical diagnostics.
Nanotechnology in Agriculture & Food: Nano-fertilizers (nano urea), pesticides (neem-oil nanoemulsion), Food packaging (Silver nanoparticles infused packaging material to increase shelf life of fruits). Water treatment (carbon nanotube membrane filters for water purification), Nanotoxicology and Biosafety.

TEXT BOOKS/ REFERENCES:

1. Nanostructures and Nanomaterials: Synthesis, Properties and Applications. G. Cao, 1st Edition, Imperial College Press, 2004.
2. Biological and Pharmaceutical Nanomaterials, Challa Kumar, 1st Edition, Wiley, Weinheim, 2006.
3. Nanoscale Technology in Biological Systems. Ralph S. Greco, Fritz B. Prinz and R. Lane Smith, 1st edition, CRC Press, 2005.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MBT5307**					
TITLE OF THE COURSE	**CLINICAL RESEARCH & TOXICOLOGY**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	**28**	**2**

COURSE OBJECTIVES:

- **To apply and evaluate** regulatory frameworks and ethical principles governing clinical trials and drug safety.
- To understand the fundamental principles of toxicology and the dose-response relationship.
- To understand the mechanisms by which toxicants affect biological systems.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	**Apply** regulatory and ethical guidelines to the design, documentation, and monitoring of clinical trials.	L3
CO2	**Assess and differentiate** organ-specific toxicities and interpret acute/chronic toxicity data.	L4
CO3	**Describe** toxicological terms, agent types, exposure routes, and biological interactions.	L2

COURSE CONTENT:

MODULE 1: CONCEPTS OF CLINICAL RESEARCH AND REGULATORY CLINICAL RESEARCH **14Hrs**

General introduction, routes of drugs administration, Dose, threshold dose, no observed effect level (NOEL), measurement of cumulative effects- time relationship. The area under the curve (AUC) of the concentration-time profiles, absolute bioavailability, Volume of Distribution (Vd). maximum tolerated dose (MTD). Basics of pharmacokinetics, calculation of pharmacokinetic estimates. Irwin profile test. Lipinski's rule for drug like molecule.

Overview of Clinical Trials: Clinical evaluation of new drug, phases of clinical trial, Preparation of clinical trial. Outline of new drug development process and drugs registration. Regulatory Perspectives of Clinical Trials: Origin and Principles of International Conference on Harmonization - Good Clinical Practice (ICH-GCP) guidelines, Ethical Committee: Institutional Review Board, Ethical Guidelines for Biomedical Research and Human Participant- Schedule Y, ICMR Informed Consent Process: Structure and content of an Informed Consent Process Ethical principles governing informed consent process. Clinical Trials: Types and Design. Experimental Study- RCT and Non RCT, Observation Study: Cohort, Case Control, Cross sectional Clinical Trial Study, Team Roles and responsibilities of Clinical Trial Personnel:

Investigator, Study Coordinator, Sponsor, CRO. Clinical Trial Documentation- Trial Monitoring- Safety Monitoring in CT Adverse Drug reaction and regulatory aspects.

MODULE 2: INTRODUCTION TO TOXICOLOGY AND TOXIC SUBSTANCES, TARGET ORGANS AND TOXICITY STUDIES	**14Hrs**

Food additives and contaminants, toxicity of pesticides, toxicity of metals, environmental pollutants, nanotoxicity, toxicological evaluation. General Concepts in Organ Toxicity -Target organ specificity, Factors influencing organ vulnerability, Role of metabolism and detoxification pathways. Hepatotoxicity, Nephrotoxicity, Neurotoxicity and Cardiotoxicity - Mechanism, toxicants and Biomarkers. Conventional studies - Acute, Short and long term. Food additives and contaminants, toxicity of pesticides, toxicity of metals, environmental pollutants, nanotoxicity, toxicological evaluation. General Concepts in Organ Toxicity -Target organ specificity, Factors influencing organ vulnerability, Role of metabolism and detoxification pathways. Hepatotoxicity, Nephrotoxicity, Neurotoxicity and Cardiotoxicity - Mechanism, toxicants and Biomarkers. Scheme of preclinical evaluation of toxicity study. Calculation of LD50& ED50.

TEXT BOOKS/ REFERENCES:

1. Casarett and Doull's Toxicology: The Basic Science of Poisons, Louis J. Casarett, John Doull, and Curtis D. Klaassen, 8th edition, McGraw-Hill Education, 2013.
2. Hayes' Principles and Methods of Toxicology, A. Wallace Hayes and Claire L. Kruger, 7th edition, CRC Press, 2021.
3. Principles of Toxicology, D. Lawrence Eaton and Steven G. Gilbert, 2nd edition, CRC Press, 2008.
4. Toxicology for Non-Toxicologists, Shayne C. Gad, 3rd edition, Academic Press, 2014.
5. General and Applied Toxicology, Bryan Ballantyne, Timothy C. Marrs, and Tore Syversen, 3rd edition, Wiley-Blackwell, 2009.
6. Introduction to Toxicology, John A. Timbrell, 4th edition, CRC Press, 2008.
7. A Textbook of Modern Toxicology, Ernest Hodgson, 4th edition, Wiley, 2010.
8. Environmental Toxicology, Karl E. Tollefsen, Rolf Altenburger, and Stefan Scholz, Latest edition, Springer, 2021.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MBT5371**					
TITLE OF THE COURSE	**TECHNIQUES IN INDUSTRIAL AND PLANT BIOTECHNOLOGY- PRACTICAL**					
SCHEME OF Instruction	Lecture Hours	Scheme Of Instruction	Lecture Hours	**Scheme Of Instruction**	Lecture Hours	**SCHEME OF Instruction**
	-	**-**	**-**	**-**	**-**	**3**

COURSE OBJECTIVES:

- To provide practical knowledge and hands-on experience in industrial biotechnology processes such as fermentation, product recovery, and enzyme production.
- To develop skills in optimizing process parameters, and maintaining laboratory safety and biosafety standards.
- Encourage critical thinking about the impact of biotechnology on sustainable agriculture.

COURSE OUTCOMES:

CO No.	**Outcomes**	**CO No.**
CO1	Students will be able to perform and analyse industrial biotechnology experiments, including fermentation and downstream processing.	CO1
CO2	Students will be able to operate bioprocess equipment and optimize production processes	CO2
CO3	Students will learn the fundamentals of culturing plant cells and tissues, culture environment, cell proliferation, differentiation, and media formulation.	CO3
CO4	**Students will be able to understand the biocontrol agents and biofertilizers formulation.**	CO4

LIST OF EXPERIMENTS

Industrial Biotechnology Practical's

1) Inoculum Preparation for Fermentation
2) Setting up shake flask culture; growth curve & determination of growth by spectroscopy
3) Strain improvement of *Aspergillus niger*
4) Production of amylase by solid substrate and submerged fermentation.
5) Optimization of amylase production using one factor at a time (OFAT)
   a) Optimization of carbon source
   b) Optimization of nitrogen source
   c) Optimization of pH
   d) Optimization of substrate

6) Statistical optimization of media: Plackett-Burman Design and RSM (Demonstration)
7) Wine Production and estimation of alcohol by specific gravity method and determination of total acidity and non-reducing sugars
8) Demonstration of Bioreactor (Application demo/ Industrial visit)

Agriculture and Plant Biotechnology

1. Preparation of plant tissue culture media
2. Isolation of plant protoplasts
3. Micropropagation of plant materials (shoot or root)
4. In vitro callus induction and estimation of phytochemical.
5. Preparation of synthetic seed by embryo
6. Isolation and characterization of soil bacteria (rhizobium).
7. Biocontrol agents and biofertilizer preparation

TEXT BOOKS/REFERENCES:

1. Industrial Biotechnology, R. Suganthi, LAP LAMBERT Academic Publishing, 1st edition, 2022.
2. Biochemical Methods, S. Sadasivam and A. Manickam, New Age International, 2022.
3. Modern Experimental Biochemistry, Rodney F. Boyer, 3rd edition, Prentice Hall, 2000.
4. Laboratory Methods in Enzymology: Protein Part A, Jon Lorsch, 1st edition, Academic Press, 2014.
5. Principles of Fermentation Technology, Peter F. Stanbury, Allan Whitaker, and Stephen J. Hall, 3rd edition, Butterworth-Heinemann, 2016.
6. Practical Manual of Agricultural Microbiology. Maheshwari, D. K. International Publishing House Pvt. Ltd. ,2013.
7. *A Practical Manual on Soil Fertility and Fertilizer Use*. Maliwal, P. L., & Others. Agrotech Publishing Academy, 2014.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MBT5372**					
TITLE OF THE COURSE	**TECHNIQUES IN TRANSLATIONAL BIOTECHNOLOGY PRACTICAL**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**-**	**6**	**-**	**72**	**3**

COURSE OBJECTIVES:

- Aims to provide students with a comprehensive understanding of advanced biotechnological techniques used in the fields of animal and medical biotechnology, as well as nanobiotechnology.
- Students will gain hands-on experience in essential laboratory procedures including animal cell culture, primary cell isolation, molecular diagnostics, and nanoparticle synthesis.
- To develop practical skills in regenerative medicine, gene editing, and antimicrobial evaluation, with an emphasis on experimental design, data analysis, and the integration of bioinformatics tools.
- Virtual simulation videos will complement wet lab experiments to enhance conceptual understanding and technical proficiency.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Demonstrate proficiency in animal cell culture techniques, including media preparation, subculturing, and maintaining sterile conditions.	L3
CO2	Apply molecular biology techniques, including transfection of mammalian cells and detection of pathogens using PCR.	L3
CO3	Utilize CRISPR-Cas9 and bioinformatics tools for understanding gene editing strategies in medical biotechnology.	L4
CO4	Synthesize and characterize silver nanoparticles and assess the antimicrobial properties of nanomaterials, demonstrating an understanding of nanobiotechnology applications.	L5

LIST OF EXPERIMENTS

Animal Biotechnology & Regenerative medicine

1. Demonstration of essential equipment (CO_2 incubator, inverted microscope. etc)
2. Animal cell culture-media preparation
3. Isolation of primary cells from animal sample
4. Trypan blue exclusion assay for cell viability
5. MTT Assay for cell proliferation and cytotoxicity
6. Scaffold preparation and cell seeding

Medical Biotechnology

1. Differential identification of bacteria (*E. coli/S. aureus*) by Polymerase Chain Reaction (PCR).
2. *In-silico* analysis of mutation.
3. Sickle test to identify sickle shaped RBCs
4. Determine susceptibility of bacteria to beta-lactam antibiotics by Kirby Bauer disc diffusion method.

   Note: Virtual videos of the experiments should supplement wet lab experiments.

Nanobiotechnology

1. Synthesis of nanoparticles using plant extract.
2. Chracterisation of nanoparticles using UV-Visible Spectroscopy.
3. Determination of antimicrobial activity of synthesized nanoparticles.

TEXT BOOKS/ REFERENCES:

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, R. Ian Freshney, 6th Edition, Wiley-Blackwell, 2010.
2. Animal Cell Biotechnology: Methods and Protocols, R. E. Spier, J. B. Griffiths, 2nd Edition, Humana Press, 2007.
3. Molecular Diagnostics: Fundamentals, Methods and Clinical Applications, Lela Buckingham, Maribeth Flaws, 2nd Edition, F.A. Davis Company, 2014.
4. Principles and Applications of Molecular Diagnostics, Nader Rifai, A. Rita Horvath, Carl T. Wittwer, 1st Edition, Elsevier, 2018.
5. Metal Nanoparticles in Microbiology, Mahendra Rai, Nelson Duran, 1st Edition, Springer, 2011.
6. Nanotechnology and Plant Sciences: Nanoparticles and Their Impact on Plants, M.N.V. Prasad, Paolo Peralta-Videa, Ajay Kumar, 1st Edition, Springer, 2015.
7. Susweta et al., 2015. Duplex PCR for specific detection of Escherichia coli and its differentiation from other Enterobacteriaceae. The Indian Journal of Animal Sciences, 85(8). https://epubs.icar.org.in/index.php/IJAnS
8. Anju et al., 2021. Green synthesis of silver nanoparticles from Aloe vera leaf extract and its antimicrobial activity https://doi.org/10.1016/j.matpr.2021.02.665
9. CHOP-CHOP web tool for selecting target site for CRISPR Cas9 - https://chopchop.cbu.uib.no

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**25MSC5401**					
TITLE OF THE COURSE	**PROJECT**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	-	**-**	**-**	**40**	**-**	**14**

OBJECTIVES

- Construct a project from Plan, schedule, monitor and control students' own work and to exhibit ideas in discussions and presentations.
- Apply tools and techniques to the applied courses taught and to communicate their findings through a written report and poster presentation.

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	To identify and define research problems relevant to life sciences and develop innovative solutions.	L2
CO2	To review and interpret scientific literature to support research objectives and design experiments using appropriate methodologies and techniques.	L3
CO3	To conduct independent laboratory/field research ethically and systematically and analyze and interpret experimental data using statistical tools.	L5
CO4	To communicate research findings effectively through thesis writing and presentations.	L6
CO5	To equip the students with hands-on training in Basic and applied sciences which prepares students for productive careers in Industries.	L5