ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Science

(NEP based Flexible Credit System)

Syllabi for M. Sc. in Biotechnology Programme

Professional Core and Elective Courses

BIRLA INSTITUTE OF TECHNOLOGY, MESRA

(Deemed to be university)

Mesra, Ranchi, Jharkhand, 835215, India

The following Members attended BoS held on 19.06.2026

[Dr. Vinod Kumar Nigam]
Member

[Dr. D. M Pandey]
Member

[Dr. Manish Kumar]
Member

[Dr. S. G. Sachan]
Member

[Dr. Alok Jain]
Member

[Dr. Koel Mukherjee]
Member

[Dr. S. R. Sharma]
Member

[Dr. Biswanish Sarkar]
Member

19/6/26
[Dr. Amit Tiwari]
Member

22/06/26
[Dr. Shashi Kumar]
External Member, from Industry & Alumni

22/06/26
[Dr. Gourav Basu Choudhury]
External Member, from Industry & Alumni

[Dr. Kunal Mukhopadhyay]
Chairman

Teaching and Learning Scheme

As per the new **National Credit Framework**, an account of 30 hours of learning is equivalent to 01 credit. It comprises of Classroom instructions (CI), Lab instructions (LI), Term work + Self Learning (TW + SL) in hours per semester. The division of the components mentioned will be as per the following teaching and learning schemes.

Sl. No.	Total credits	Classroom Instructions (CI) in hours per semester		Lab Instructions (LI) in hours per semester	Term work (TW)and Self Learning (SL) (TW + SL) in hours per semester	Total no. of Hours per semester
		Lectures	Tutorials			
1	**04 (Four) Theory**	42	14	0	64	120
2	**03 (Three) Theory**	28	14	0	48	90
3	**03 (Three) Theory**	42	0	0	48	90
4	**02 (Two) Theory**	28	0	0	32	60
5	**02 (Two) Lab**	0	0	56	4	60
6	**1.5 (One and half) Lab**	0	0	42	3	45
7	**01 (One) Lab**	0	0	28	2	30
8	**02 (Two) Project**	0	0	0	60	60
9	**03 (Three) Project**	0	0	0	90	90
10	**06 (Six) Project**	0	0	0	180	180
11	**03 (Three) Vocational**	14	0	56	20	90

Legend:

CI Classroom Instruction (includes different instructional/ implementation strategies i.e. Lecture (L), Tutorial (T), case method, Demonstrations, video demonstration, problem-based learning etc. to deliver theoretical concepts)

LI Laboratory Instruction (includes experiments/ practical performances, problem-based experiences in laboratory, workshop, field or other locations using different instructional/ implementation strategies)

TW Term Work (includes assignments, seminar micro projects, industrial visits, any other student activities etc.)

SL Self Learning, MOOCs, spoken tutorials, online educational resources etc. (if provided in curriculum structure)

Signed by:

Dr. Sandeep Singh Solanki
Dean (PGS)
Chairperson

Dr. Gautam Sarkhel
Dean (UGS)
Member

Dr. Raju Poddar
Dean (RIE)
Member

Dr. Praveen Srivastava
Dean (SA)
Member

Dr. Ashoke Sharon
Dean (FA)
Member

Dr. Manish Kumar
Dean (AAC)
Member

Dr. Ritesh Kumar Singh
Controller of Examination
Member

Dr. Animesh Ghosh
Director (IQAC)
Member

Dr. Rajesh Jain
Registrar
Member

Dr. Sukalyan Chakroborty
Associate Dean (UGS & PGS)
Member

Mr. Siddhi Kant Mishra
Asst. Registrar (Acad. Prog.)
Member Secretary

Department of Bioengineering and Biotechnology

Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

- To educate students at Undergraduate, Post Graduate Doctoral and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

The Department has a vision to impart international standard quality education in the field of Bioscience, Biotechnology and Bioengineering.

Department Mission

- To create state-of-the-art infrastructure for Research and Training in Biotechnology and Bioengineering.
- To provide globally acceptable technical education in Bioscience, Biotechnology and Bioengineering.
- To nurture graduates for innovation and creativity in the field of Bioscience, Biotechnology and Bioengineering having ethical and social concern.
- To promote collaboration with Academia, Industries and Research Organizations at National and International level to enhance quality of education and research.
- To contribute to socioeconomic development through education and bioentrepreneurship.

M. Sc. (Biotechnology)

Programme Educational Objectives (PEOs)

PEO1	Students will gain necessary knowledge and develop specialized skills in the different areas of Biotechnology.
PEO2	Students will think critically and creatively about the use of biotechnology to address local and global problems.
PEO3	Students will be able to implement the scientific skills for development of industrial applications and entrepreneurship.

Program Outcomes (POs)

PO1	Ability to carry out research /investigation independently in specialized area of Biotechnology.
PO2	Ability to write and present a substantial technical report/document.
PO3	Able to demonstrate a degree of mastery in the area of biotechnology to enable them in collaborative and multidisciplinary research.
PO4	Recognize the need for continuous learning and will prepare oneself to create, select, learn and apply appropriate techniques, resources, and modern instrumentation to solve complex biotechnological activities with an understanding of the limitations.
PO5	Demonstrate knowledge of biotechnology and management principles and apply to manage projects efficiently and economically with intellectual integrity and ethics for sustainable development of society.
PO6	Recognize opportunities and contribute to collaborative-multidisciplinary research, demonstrate a capacity for teamwork, decision-making based on open-mindedness and rational analysis in order to achieve common goals.

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEW COURSE STRUCTURE – To be effective from academic session 2026-27
Based on NEP-2020 model
M. Sc. Programme in Biotechnology

Semester/ Session of Study (Recommended)	**Level**	**Category of course**	**Course Code**	**Course**	**Mode of delivery & credits** *L-Lecture; T-Tutorial; ?-Practicals*			**Total Credits** C- *Credits*
					L ***(Periods / week)***	**T** ***(Periods / week)***	**p** ***(Periods/ week)***	**C**
FIRST/ Monsoon	**FOURTH**	**THEORY**						
		Programme Core (PC)	BT26401	Molecular Cell Biology	3	0	0	3
			BT26403	Applied Microbiology	3	0	0	3
			BT26405	Metabolism and Bioenergetics	3	0	0	3
			BT26407	Mathematics and Statistics for Biologists	3	0	0	3
		Programme Elective (PE)		PE I	3	0	0	3
		Skill development I	BT26406	IPR, Biosafety & Technical Writing in Biotechnology	0	1	2	2
		LABORATORIES						
		Programme Core (PC)	BT26402	Cell Biology and Biochemistry Lab	0	0	3	1.5
			BT26404	Microbiology Lab	0	0	3	1.5
		TOTAL						**20**
SECOND/ Spring	**FOURTH**	**THEORY**						
		Programme Core (PC)	BT26409	Molecular Biology & Recombinant DNA Technology	3	0	0	3
			BT26411	Enzyme and Bioprocess Technology	3	0	0	3
			BT26413	Bioinformatics	3	0	0	3
			BT26415	Analytical Techniques in Biotechnology	3	0	0	3
		Programme Elective (PE)		PE II	3	0	0	3
		Skill development II	BT26412	Professional Practice & Entrepreneurships	0	1	2	2
		LABORATORIES						
		Programm	BT26408	Enzyme and Bioprocess	0	0	3	1.5

		e Core (PC)		Technology Lab				
			BT26410	Genomics and r-DNA Technology Lab	0	0	3	1.5
								20
TOTAL FOR THIRD LEVEL								**40**

THIRD/ Monsoon	**FIFTH**	**THEORY**						
		Programme Core (PC)	BT26501	Immunotechnology	3	0	0	3
			BT26503	Environmental Biotechnology	3	0	0	3
			BT26505	Concepts in Nanobiotechnology	2	0	0	2
		MOOC/ Open Elective		MOOC/ Open Elective	3	0	0	3
		LABORATORIES						
		Programme Core (PC)	BT26502	Immunotechnology Lab	0	0	3	1.5
			BT26504	Environmental Biotechnology Lab	0	0	3	1.5
		Research Project (RP)	BT26500	Dissertation Part I				6
		TOTAL						**20**
FOURTH/ Spring	**FIFTH**	Research Project (RP)	BT26550	Dissertation Part II				20
		TOTAL						**20**
TOTAL FOR FOURTH LEVEL								**20**
GRAND TOTAL FOR M.Sc PROGRAMME								**80**

DEPARTMENT OF BIOENGINEERING & BIOTECHNOLOGY

PROGRAM ELECTIVES (PE) FOR M.Sc
LEVEL OFFERED FOR LEVEL 4-5

PE/LEVEL	Code no.	Name of the PE courses	Prerequisites/Corequisites courses with code	L	T	p	C
Programme Elective -I							
PE/4 (MO)	BT26417	Genomics	NIL	3	0	0	3
PE/4 (MO)	BT26419	Industrial Biotechnology	NIL	3	0	0	3
PE/4 (MO)	BT26421	Molecular Plant Physiology	NIL	3	0	0	3
PE/4 (MO)	BT26423	Biosignal Acquisition System	NIL	3	0	0	3
Programme Elective -II							
PE/4 (SP)	BT26425	Proteomics	BT405	3	0	0	3
PE/4 (SP)	BT26427	Biomedical Instrumentation	BT411	3	0	0	3
PE/4 (SP)	BT26429	Molecular Genetics & Pharmacogenomics	NIL	3	0	0	3
PE/4 (SP)	BT26431	Systems Biology	NIL	3	0	0	3

COURSE INFORMATION

Course code	BT26401
Course title	Molecular Cell Biology
Pre-requisite(s)	NA
Co-requisite	NA
Credits	3
Class schedule per week	L: 3 T: 0 P:0
Class	MSc
Semester / Level	I
Branch	Biotechnology
Name of Teacher	Dr. Dinesh Prasad

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	Provide a comprehensive understanding of cellular organization, structure, and function of prokaryotic and eukaryotic cells.
2.	Develop fundamental knowledge of biomolecules, gene regulation, cellular metabolism, and experimental techniques used in modern cell biology.
3.	Explain the structural and functional organization of the cytoskeleton, extracellular matrix, and cell adhesion mechanisms.
4.	Understand the molecular basis of cell signaling, intercellular communication, and regulation of cellular responses.
5.	Introduce the mechanisms governing cell cycle progression, differentiation, apoptosis, and cancer development.
6.	Familiarize students with the role of oncogenes, tumor suppressor genes, epigenetic regulation, and non-coding RNAs in cancer biology.
7.	Develop the ability to critically analyze cellular processes and their implications in biotechnology, human health, and disease.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Explain the structural organization and functional significance of cellular components, membranes, and organelles.
CO2	Interpret the molecular basis of gene expression, epigenetic regulation, non-coding RNAs, and experimental techniques in cell biology.
CO3	Analyze cytoskeletal organization, extracellular matrix interactions, cell adhesion, and cellular motility.
CO4	Evaluate cellular communication, signal transduction pathways, and regulatory mechanisms in plants and animals.
CO5	Explain mechanisms of cell cycle regulation, differentiation, apoptosis, and stem cell biology.
CO6	Assess the molecular basis of cancer including oncogenes, tumor suppressor genes, metastasis, carcinogenesis, and molecular diagnostics.

Syllabus

Module No.	Module name	Detailed Contents	No. of Lecture
I	Cell Structure and Organization:	Structure of prokaryotic and eukaryotic cells, Cellular compartmentalization and organelle organization, Structure and function. Biomembrane structure and composition, Membrane carbohydrates and cell-cell recognition, Transmembrane transport of ions and small molecules, Protein targeting and trafficking to membranes and organelles, Intracellular vesicular transport, secretion, endocytosis, and exocytosis, Neurotransmission and its regulation. Use AI tools to classify cell types from microscopic images.(tools: CellProfiler, DeepCell, ImageJ with AI plugins)	8
II	Cellular Macromolecules, Gene Regulation and Experimental Cell Biology	Structure, properties, and functions of DNA, RNA, and proteins, Chromatin organization, nucleosome structure, and higher-order genome packaging, Fundamentals of molecular biology: DNA replication, transcription, and translation, Epigenetic regulation of gene expression: DNA methylation, histone modifications, and chromatin remodeling, Roles of non-coding RNAs in development and cancer, Mitochondrial dysfunction and metabolic alterations in disease and cancer, Manipulation and analysis of proteins, DNA, and RNA. Protein structure prediction using AlphaFold.	8
III	Cytoskeleton, Cell Adhesion and Extracellular Matrix:	Self-assembly and organization of cytoskeletal filaments, Microfilaments, intermediate filaments, and microtubules, Cytoskeletal dynamics and regulation, Molecular motors: myosin, kinesin, and dynein, Structure and function of cilia and flagella, Cell-cell and cell-matrix interactions, Extracellular matrix organization and remodeling, Plant cell wall structure and function, Cell junctions: Tight junctions, Adherens junctions, Desmosomes, Hemidesmosomes, Gap junctions, Plasmodesmata, Genes regulating cell motility and adhesion. Cell migration prediction using AI software (TrackMate).	8
IV	Cell Signaling and Intercellular Communication:	General principles of cell communication, Signal transduction mechanisms, Signaling through G-protein-coupled receptors (GPCRs), Signaling through enzyme-linked receptors, Receptor tyrosine kinase signaling pathways, Signaling mediated by regulated proteolysis, Intracellular signaling networks and second messengers,	8

		Signaling pathways regulating gene expression, Plant hormones and growth regulators, Host-parasite interactions, Genes involved in cellular communication and signaling. AI-based reconstruction of signaling pathways.	
V	Cell Cycle and Differentiation and Cancer Biology:	Overview of the cell cycle control system, Cyclins, cyclin-dependent kinases (CDKs), and checkpoints, Intracellular and extracellular regulation of cell division, Cell growth and apoptosis, Stem cells and cellular differentiation, Nomenclature and classification of tumors, Characteristics of benign and malignant neoplasms, Hallmarks of cancer, Oncogenes and proto-oncogenes, Tumor suppressor genes (RB, p53, APC, PTEN), Cancer metabolism and Warburg effect, Angiogenesis, invasion, and metastasis, Cancer stem cells, Genomic instability and epigenetic alterations, Chemical, radiation, and microbial carcinogenesis, Tumor immunology and immune evasion, Molecular diagnostics, tumor biomarkers, and DNA/RNA vaccines and use of AI in vaccines design. The Cancer Genome Atlas (TCGA).	8

Learning Resources	
Text Books	***Reference Books***
Molecular Biology of the Cell	Molecular Cell Biology
The Biology of Cancer	Lewin's Genes
Cell and Molecular Biology: Concepts and Experiments	Robbins and Cotran Pathologic Basis of Disease

Gaps in the Syllabus (to meet Industry/Profession requirements)	***Nil***
Pos met through Gaps in the Syllabus	***Nil***
Topics beyond syllabus/Advanced topics/Design	***Nil***
Pos met through Topics beyond syllabus/Advanced topics/Design	***Nil***

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1: Explain the structural organization and functional significance of cellular components, membranes, and organelles.	2	1	3	2	1	1
CO2: Interpret the molecular basis of gene expression, epigenetic regulation, non-coding RNAs, and experimental techniques in cell biology.	3	1	3	3	1	2
CO3: Analyze cytoskeletal organization, extracellular matrix interactions, cell adhesion, and cellular motility.	2	1	3	2	1	2
CO4: Evaluate cellular communication, signal transduction pathways, and regulatory mechanisms in plants and animals.	3	1	3	3	1	2
CO5: Explain mechanisms of cell cycle regulation, differentiation, apoptosis, and stem cell biology.	3	1	3	2	2	2
CO6: Assess the molecular basis of cancer including oncogenes, tumor suppressor genes, metastasis, carcinogenesis, and molecular diagnostics.	3	2	3	3	2	2

Correlation Level: 3 = High, 2 = Moderate, 1 = Low, Blank = No Correlation.

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CO1, CO2, CO6
CO2	CO1, CO2, CO4, CO6
CO3	CO1, CO2, CO6
CO4	CO1, CO2, CO4, CO6
CO5	CO1, CO2, CO3, CO6

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CO1, CO2, CO6
CO2	CO1, CO2, CO4, CO6
CO3	CO1, CO2, CO6
CO4	CO1, CO2, CO4, CO6
CO5	CO1, CO2, CO3, CO6

Course Designers		
Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*

COURSE INFORMATION

Course code	BT 26403
Course title	Applied Microbiology
Pre-requisite(s)	Nil
Co-requisite	Microbiology Lab
Credits	3
Class schedule per week	L: 3 T: 0 P: 0
Class	MSc
Semester / Level	I/4th
Branch	Biotechnology
Name of Teacher	Dr. Shashwati Ghosh (Sachan)

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	An understanding of the basic techniques (concept of aseptic work, cultivation and identification) in microbiology
2.	Description of different aspects of microbial nutrition and growth
3.	Explanation of microbial interactions and their significance in the environment
4.	Details of microbial interactions and their significance in agriculture, food and pharmaceuticals
5.	Description of normal microbiota in human body, nonspecific body defences and apply this understanding to the infectious disease process as well as the prevention and control of infectious diseases
6.	To develop and execute oral and writing skills necessary for effective communication of the course, the ability to think critically regarding a topic and the delivery of scientific principles to both scientists and non-scientists community

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Apply fundamental microbiological techniques and identify microorganisms using standard techniques
CO2	Analyse microbial nutrition and growth dynamics
CO3	Evaluate the impact of microorganisms on the environment in both beneficial and detrimental ways. Identify emerging applications of artificial intelligence (AI) in environmental microbiology
CO4	Assess impact of plant- microbe interaction on agriculture in both beneficial and detrimental ways. Identify industrially important microorganisms and their applications, including AI integration in industrial microbiology
CO5	Determine ways in which microorganisms play an integral role in disease, the non-specific host defence mechanisms and methods of disease treatment/prevention

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1.	Techniques in Microbiology & Microbial Diversity	Microscopy, Staining in Microbiology, Sterilization, Pure culture Methods, Culture Media and its types, Micrometry, Air Sampling, Waste water analysis, Measurement of Microbial Growth, Methods of identification of microorganisms	8
2.	Microbial Nutrition and Growth	Nutritional and Growth Factors requirement of microorganisms, Uptake of Nutrition, Microbial Growth, Influence of Environmental Factors of Growth, Batch Culture, Continuous Culture, Synchronous Growth, Fed-batch Culture. Control of microbial growth by physical and chemical agents	8
3.	Environmental Microbiology	Air Microbiology, Allergic disorders by air microflora, Air borne diseases and prevention, Water and wastewater treatment, Bacteriological analysis of water, Bioleaching, Bioremediation, Role of AI in bioremediation	8
4.	Agricultural Microbiology and Industrial Microbiology	Plant-microbe interactions, Biofertilizers, Microbial Biodeterioration of agricultural products, Control of microbes and safe storage of agricultural products, Microbiology of foods, Industrially important microorganisms, Application of AI in Industrial microbiology	8
5.	Medical Microbiology	Normal microbiota of human host, Diseases caused by bacteria, virus, fungi, and protozoans to humans, Host pathogen interaction, Toxins produced, Non-specific defences, Anti-microbial agents, Vaccines, National Immunization Programme	8

Learning Resources	
Text Books	***Reference Books***
1. Willey, Sandman, Wood, Prescott's Microbiology, 11th Ed., TMH, 2019	1. Pelczar, Chan and Krieg, Microbiology, 5th Ed., McGraw Hill, 1985
2. Frazier and Westhoff, Food Microbiology, 4th Ed., TMH, 1995	

Gaps in the Syllabus (to meet Industry/Profession requirements)	Nil
Pos met through Gaps in the Syllabus	Nil
Topics beyond syllabus/Advanced topics/Design	Nil
Pos met through Topics beyond syllabus/Advanced topics/Design	Nil

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO 5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	3	3	3
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	2	2	3	3	3	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

Course code	BT26405
Course title	Metabolism and Bioenergetics
Pre-requisite(s)	Graduate
Co-requisite	Basic concepts of Biomolecules
Credits	3
Class schedule per week	L: 3 T:0 P:0
Class	M.Sc.
Semester / Level	1st / Fourth
Branch	Biotechnology
Name of Teacher	Dr. Sheela Chandra

COURSE INFORMATION

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	To give basic knowledge about catabolism, anabolism, regulation of metabolism and pathway analysis.
2.	To acquire comprehensive knowledge of biochemical pathways involved in intermediary metabolism and understanding of enzyme activity mechanism and regulation.
3.	To study metabolic pathways of amino acids and nucleic acids and their regulation.
4.	To gain knowledge about the thermodynamic aspects of bioenergetics in living system
5.	To introduce the principles and applications of Artificial Intelligence in solving biochemical problems

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Demonstrate an understanding of carbohydrate, protein, lipid and nucleic acid metabolism.
CO2	Distinguish between different metabolic processes and their impact in metabolism of biomolecules.
CO3	Interpret metabolic pathways and their role in biological systems.
CO4	Apply and analyse the knowledge related to bioenergetics in living system.
CO5	Apply basic AI tools and approaches to analyze biochemical data and interpret biological systems.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
1.	Introduction to Metabolism	Catabolism, anabolism, metabolic classifications of organisms, metabolic strategies and regulation, methods employed to study metabolism and pathway analysis, Integration of metabolic pathways.	8
2.	Carbohydrate & Fat Metabolism	Glycolysis, Citric acid cycle, Gluconeogenesis, Glycogenesis, Glycogenolysis, Hexose monophosphate shunt, Galactose metabolism, Fructose metabolism, mucopolysaccharides metabolism, Biosynthesis, degradation and regulation of fatty acids, Membrane lipids	8
3.	Protein and Nucleic Acid Metabolism	Metabolism and regulation of amino acids, Urea cycle, Transamination, Deamination, Metabolism and regulation of nucleotides, *De novo* & salvage pathways.	8
4.	Bioenergetics/Thermodynamics	Laws of thermodynamics, Concept of free energy, entropy, enthalpy and their relationship, Application of free energy function, Integration of metabolic pathways of energy metabolism.	8
5.	AI applications in Biochemistry	Basics of AI and Machine Learning in biological systems, Protein structure prediction and functional annotation, AI in drug discovery, Metabolic pathway prediction using AI, Sequence alignment using ML & BLAST	8

Learning Resources	
Text Books	***Reference Books***
Geoffrey L. Zubey, Biochemistry, Fourth Edition: Wm.C. Brown Publishers, 1998	D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; 8th ed.NewYork
U. Satyanarayana and U. Chakrapani: Biochemistry	Biochemistry 5th Revised edition by Lubert Stryer, Jeremy M. Berg, John L. Tymoczko (ISBN: 8601300395166)
Biochemistry by Robert Roskoski. W.B. Saunders, Philadelphia, ISBN 0-7216-5174-7	Machine Learning for absolute Beginners:Oliver Theobald
Bioinformatics: Sequence and Genome Analysis-David W Mount	Artificial Intelligence in Drug discovery, Edited by Nathan Brown

Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	
Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	2	2	2
CO2	2	2	3	2	2	2
CO3	2	2	3	3	2	3
CO4	2	2	3	3	3	3
CO5	1	2	3	3	3	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD4
CO4	CD1, CD2, CD3, CD4
CO5	CD1, CD2, CD3, CD4, CD5, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26407
Course title	Mathematics and Statistics for Biologists
Pre-requisite(s)	NA
Co-requisite	NA
Credits	L: 3 T:0 P:0
Class schedule per week	3
Class	MSc
Semester / Level	I/04
Branch	Biotechnology
Name of Teacher	Dr. Raju Poddar

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	Work on basic science as well as biotech industry in multidisciplinary teams and independently.
2	Learn various tools to design, conduct, mathematical & statistical analysis new experiments, measurements and interpreting experimental data from biological system and addressing the challenges associated with the interaction between living systems and non-living materials.
3	Grab the knowledge theory of basic mathematical & statistical tools used in biological research/ biotechnology industry and research lab (Probability, Sampling Theory and Test of Hypothesis).
4	Enable the students to understand the principle and application of Correlation, Differential Equations and various Computational Techniques
5	A Master's degree in this field prepares a student for careers in biotech research in different domains including industry.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
1	An ability to apply knowledge of mathematics and statistics to design and conduct experiments, as well as to analyze and interpret data related to domain of biology.
2	An ability to design a system, component, or process to performing research in biological system and addressing the challenges associated with the interaction between living systems and non -living materials. Know how to meet the desired needs within realistic constraints, such as, economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
3	An ability to apply the knowledge of basic mathematical & statistical tools used in biological research/ biotechnology in industry and research lab.
4	Evaluate the effectiveness and limitations of mathematical strategies for biotechnology and biomedical applications.
5	A Master's degree in this field prepares a student for careers in higher education, as well as in pharmaceutical and biotechnology industries in government and private agencies. An ability to function in multidisciplinary teams. An ability to identify, formulate, and solve Science/Engineering problems.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
I	Mathematical Foundations for Biological Sciences	Sets, Matrices and determinants, Scalars, Vectors and vector spaces, Eigen values & eigen vectors. Basics of differential calculus, rates of change, enzyme kinetics (Michaelis-Menten), and their applications in biological growth, enzyme kinetics.	8
II	Descriptive Statistics and Data Presentation	Introduction to statistics, types of biological data, tabulation, and graphical representation, Exploratory Data Analysis (EDA), box plots, histograms, violin plots, heatmaps. Measures of central tendency (mean, median, mode) and dispersion (variance, standard deviation, coefficient of variation) with applications in biological data analysis.	8
III	Probability, Probability Distributions and Statistical Inference	Basic concepts of probability, conditional probability, Bayes' theorem, and random variables. Binomial, Poisson, normal, Student's t, and chi-square distributions. Hypothesis testing, Type I and Type II errors, sample size. Applications in biological experiments and omics studies.	8
IV	Correlation, Regression and Non-Parametric Methods	Pearson and Spearman correlation, simple and multiple linear regression, logistic regression, Analysis of variance (ANOVA), Principal Component Analysis (PCA), hierarchical clustering, k-means clustering, dimensionality reduction techniques for biological datasets. Non-parametric tests: Mann-Whitney U, Friedman test.	8
V	Applications of Mathematics and Statistics in Biotechnology Research	Experimental design (CRD and RBD), statistical analysis of genomics, proteomics data. Introduction to machine learning concepts: supervised and unsupervised learning, Decision Trees, k-Nearest Neighbors (k-NN), Neural Networks (ANN). Applications in biomarker discovery, using R/Python. Case studies from recent biotechnology research.	8

Learning Resources	
Text Books	***Reference Books***
1. Fundamentals of Mathematics by William M. Setek, Jr. And Michael A. Gallo, Prentice Hall, ISBN- 0 -13 - 778341 -8. 2. Basic Technical Mathematics with Calculus by Allyn J. Washington, Addison- Wesley Publishing Company	

Gaps in the Syllabus (to meet Industry/Profession requirements)	Design of real-time industrial projects.
Pos met through Gaps in the Syllabus	***Nil***
Topics beyond syllabus/Advanced topics/Design	***Nil***
Pos met through Topics beyond syllabus/Advanced topics/Design	***Nil***

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	1	1	-
CO2	2	3	1	1	-	-
CO3	3	2	3	2	1	1
CO4	3	3	1	2	1	1

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD3, CD6
CO3	CD1, CD2, CD3
CO4	CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26406
Course title	IPR, Biosafety and technical writing in Biotechnology
Pre-requisite(s)	NA
Co-requisite	NA
Credits	2
Class schedule per week	L: 0 T: 1 P:2
Class	M.Sc
Semester / Level	I/5
Branch	Biotechnology
Name of Teacher	Dr. Hare Ram Singh

Course Objectives ***This course aims to provide students with:***	
Sl No.	**Objectives**
1	To introduce students to Intellectual Property Rights (IPR) and biosafety regulations relevant to biological sciences.
2	To develop scientific and technical writing skills for academic and professional communication.
3	To enhance oral presentation and scientific dissemination skills.
4	To prepare students for research, industry, entrepreneurship, and higher studies.

Course Outcomes (COs) ***Upon successful completion of the course, students will be able to***	
CO	**Course Outcomes**
CO 1	Understand various forms of IPR and their significance in biotechnology.
CO 2	Apply biosafety and bioethical principles in laboratory and research environments.
CO 3	Prepare scientific reports, technical documents, and research summaries.
CO 4	Demonstrate professional communication skills in academic and industrial settings.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
1	**Introduction to IPR:**	Introduction to Intellectual Property Rights, Types of IPR, Patents, Copyrights, Trademarks, Trade Secrets and Geographical Indications, Importance of IPR in	**6**

		Biotechnology, Patentable and Non-Patentable Inventions. Agreements and Treaties, Indian patent act 1970 & recent amendments.	
2	**Basics of Patent and Concept of Prior Art:**	Type of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete. Basics of Patent Filing procedure, Biotechnology Patents: Case Studies	**6**
3	**Biosafety and Regulatory Framework:**	Principles of Biosafety, Laboratory Biosafety Levels (BSL-1 to BSL-4), Good Laboratory Practices (GLP), Recombinant DNA Safety Guidelines	**5**
4	**Technical Writing and Structured Documentation:**	Drafting reports, research papers, thesis, understanding document structure and referencing styles (APA/IEEE basics) and tools. Formatting text, equations, tables figures, Bibliography and Citation. Avoiding Plagiarism and using AI writing assistants ethically.	**5**
5	**Effective Presentation and Professional Communication Skills:**	Slide design (Clarity, Visuals, minimal text), Structuring a presentation, data visualization, presentation tools (PPT, Google slide/Slides/Canva), Poster Design. Voice modulation, Body language, Handling Q&A session.	**5**

Learning Resources	
Text Books	***Reference Books***
Deepa Goel. *IPR, Biosafety and Bioethics*	Sateesh, M.K. *Bioethics and Biosafety*.
Day, R.A. & Gastel, B. *How to Write and Publish a Scientific Paper*.	WIPO Training Materials on Intellectual Property.
Alley, M. *The Craft of Scientific Presentations*.	COPE Guidelines on Publication Ethics.
Ganguli, P. *Intellectual Property Rights: Unleashing the Knowledge Economy*.	DBT Biosafety Guidelines, Government of India.
WHO. *Laboratory Biosafety Manual*.	
Gaps in the Syllabus (to meet Industry/Profession requirements)	***Nil***
Pos met through Gaps in the Syllabus	***Nil***
Topics beyond syllabus/Advanced topics/Design	***Nil***
Pos met through Topics beyond syllabus/Advanced topics/Design	***Nil***

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	**100%**				
	Continuous Internal Assessment	***% Distribution***				
	Best 3 Quiz marks out of 4 Quizzes of 20 marks each.	**60%**				
	Assignment(s)	**20%**				
	Seminar before a Committee	**20%**				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***

	Continuous Internal Assessment					

Indirect Assessment	

Course Delivery Methods	
CD1	**Lecture by use of boards/LCD projectors/OHP projectors**
CD2	**Assignments/Seminars**
CD3	**Laboratory experiments/teaching aids**
CD4	**Industrial/guest lectures**
CD5	**Industrial visits/in-plant training**
CD6	**Self- learning (SL) such as use of NPTEL materials and internets**
CD7	**Simulation**

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	**CD1, CD2, CD6**
CO2	**CD1, CD2, CD6**
CO3	**CD1, CD2, CD6**
CO4	**CD1, CD2, CD6**

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26402
Course title	Cell Biology and Biochemistry Lab
Pre-requisite(s)	NA
Co-requisite	BT26401, BT26402
Credits	1.5
Class schedule per week	L: T: P:3
Class	
Semester / Level	1st
Branch	Biotechnology
Name of Teacher	Dr. Dinesh Prasad

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	To establish an understanding of the basic techniques (concept of aseptic work, cultivation and identification) in microbiology
2.	To describe different aspects of microbial nutrition and growth
3.	To describe microbial interactions and their significance in environment
4.	To describe microbial interactions and their significance in agriculture, food and pharmaceuticals
5.	To develop and execute oral and writing skills necessary for effective communication of the course, the ability to think critically regarding a topic and the delivery of scientific principles to both scientists and non-scientists community

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Identify microbiological techniques, the defining characteristics of the major groups of microorganisms and apply to study microbial phylogeny
CO2	Classify the methods to measure microbial growth
CO3	Evaluate how microorganisms interact with the environment in beneficial or detrimental ways
CO4	Identify industrially important microbes
CO5	Apply the scientific method by stating a question; researching the topic; determining appropriate tests; performing tests; collecting, analyzing, and presenting data and effective communicate with both specialist and non-specialist audiences/community

Syllabus

Sl. No.	***List of Experiments***	***No. of Lecture***
1.	Preparation of Buffers.	
2.	Qualitative Test for Carbohydrates.	
3.	Qualitative Test for Amino Acids.	
4.	Carbohydrate estimation by Anthrone.	
5.	Protein Estimation by Bradford Method.	
6.	Protein Estimation by Lowry Method.	
7.	Isolation and Estimation of DNA.	
8.	Protein precipitation and purification SDS PAGE.	
9.	Preparation of slides of mitosis from onion root tip cells.	
10.	Study of different types of cells in the human blood smear.	
11.	Identification of Barr bodies in the human cheek cells.	
12.	To study the effect of plasmolysis and deplasmolysis in onion peel.	
13.	To study the working of Compound microscope.	
14.	To measure the length and breadth of the given cell sample by using	
15.	To identify the number of cells present in the given 1ml sample with help of haemocytometer.	
16.	To identify the different types cells present in the leaf cross section.	

Learning Resources	
Text Books	***Reference Books***
Gerczei Fernandez, Timea / Pattison, Scott: Biochemistry laboratory manual for undergraduates: An inquiry-based approach, SCIENDO, Open Access PDF ISBN 978-3-11-041133-1	Arun Rastogi: Laboratory Manual in Biochemistry, Anmol Publisher (2011) ISBN-10: 8126144998

Gaps in the Syllabus (to meet Industry/Profession requirements)	**Nil**
Pos met through Gaps in the Syllabus	**Nil**
Topics beyond syllabus/Advanced topics/Design	**Nil**
Pos met through Topics beyond syllabus/Advanced topics/Design	**Nil**

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	3	3	3
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	2	2	3	3	3	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

(3 = Strong, 2 = Moderate, 1 = Low Contribution)

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6
CO1: Apply knowledge of cell biology and biochemistry in understanding cellular functions and life processes.	2	1	3	2	1	1
CO2: Design and analyze experiments related to biomolecules and cellular processes using molecular biology techniques.	3	2	3	3	1	2
CO3: Identify, formulate and solve problems arising from inefficient functioning of biological systems.	3	1	2	2	2	2
CO4: Use modern laboratory techniques, collect and analyze data, interpret results and design research projects.	3	3	3	3	2	2

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD2, CD3, CD4
CO2	CD4, CD2, CD6
CO3	CD4, CD2, CD3
CO4	CD3, CD2,CD4
CO5	CD3, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT 26404
Course title	Microbiology Lab
Pre-requisite(s)	Nil
Co-requisite	BT 26403 Applied Microbiology
Credits	1.5
Class schedule per week	L: T: P: 3
Class	MSc
Semester / Level	I/4th
Branch	Biotechnology
Name of Teacher	Dr. Shashwati Ghosh (Sachan)

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	An understanding of the basic handling skills of isolation and cultivation of microorganisms using serial dilution and plating techniques
2.	Standard techniques for the identification of microbes using staining, biochemical tests
3.	Competence in measuring the size of microorganisms and analyzing microbial growth patterns
4.	Standard techniques for antimicrobial susceptibility testing and detection of resistant microbes
5.	Ability to execute oral and experimental skills necessary for effective communication of the course, the ability to think critically regarding a topic and the delivery of scientific principles to both scientists and non-scientists community

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Perform microbial isolation and cultivation and apply staining techniques for identification of microorganisms and examine microbial morphology under a microscope accurately
CO2	Perform biochemical tests for screening and identification of microorganisms and interpret the results effectively
CO3	Determine size of microorganism using micrometry and analyze different phases of microbial growth
CO4	Perform antibiotic susceptibility tests and screen antibiotic resistant bacteria
CO5	Follow biosafety and laboratory protocols during microbiological work, Develop experimental and analytical skills, Record, analyze, and interpret experimental data

Syllabus

List of Experiments

Sl. No.	Experiment Name
1.	To isolate microorganisms from the soil sample by using serial dilution, spread plate, and pour plate methods
2.	To obtain pure colonies isolated from soil by streak plate method
3.	Staining techniques in microbiology
4.	To perform biochemical tests for screening of microorganisms
5.	To determine the size of microorganism using micrometry
6.	To study the different phases of bacterial growth
7.	To perform antibiotic susceptibility test of bacterial culture
8.	To isolate antibiotic-resistant bacteria from water sample

Learning Resources	
Text Books	***Reference Books***
1. James G. Cappuccino and Natalie Sharman: Microbiology: A laboratory Manual, 7th Edition, Dorling Kindersley (India) Pvt.Ltd., 2005	

Gaps in the Syllabus (to meet Industry/Profession requirements)	***Nil***
Pos met through Gaps in the Syllabus	***Nil***
Topics beyond syllabus/Advanced topics/Design	***Nil***
Pos met through Topics beyond syllabus/Advanced topics/Design	***Nil***

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	60%				
	Semester End Examination	40%				
	Continuous Internal Assessment	***% Distribution***				
	Quiz I	10%				
	Lab record	30%				
	Viva	20%				
	Semester End Examination	% Distribution				
	Lab experimental performance	30%				
	Quiz	10%				
	Semester End Examination	% Distribution				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	3	3	3
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	3	3	3	3	3	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD3
CO2	CD1, CD3
CO3	CD1, CD3
CO4	CD1, CD3
CO5	CD1, CD3

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26409
Course title	Molecular Biology & Recombinant DNA Technology
Pre-requisite(s)	NA
Co-requisite	NA
Credits	3
Class schedule per week	L: 3 T:0 P: 0
Class	MSc
Semester / Level	II
Branch	Biotechnology
Name of Teacher	Dr. Kunal Mukhopadhyay

Course Objectives
This course aims to provide students with:

Sl No.	Objectives
1.	Impart knowledge on basic concepts of various molecular biology techniques
2.	Exemplify different types of polymerase chain reactions and their applications
3.	Implement, organize and design different vectors for gene cloning and expression
4.	Generating contextual and conditional knowledge of gene function for various applications
5.	Impart knowledge on basic concepts of various molecular biology techniques

Course Outcomes (COs)
Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Apply the principles of molecular biology techniques.
CO2	Analyse the experimental data using AI to select suitable PCR for particular applications
CO3	Evaluate selectivity and specificity of vectors for cloning genes and their expressions
CO4	Apply AI to examine gene function, gene modulation and their effects on improvement of crops and animals.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
1	Genetic Organization	Central dogma of molecular biology, structure of DNA, DNA replication, DNA damage and repair, Discovery and salient features of genetic code, organellar genetic code. RNA synthesis, processing and editing, Protein synthesis and Posttranslational modifications of proteins	8
2.	Gene Regulation:	Differences in genetic organization of prokaryote and eukaryote, lac operon, regulation of bacteriophage λ life cycle, nucleic acid binding motifs in regulatory proteins, Small Double stranded RNAs and RNA interference, AI-based designing of miRNA constructs; Epigenetics	8
3	Methods in Genetic Engineering	Polymerase Chain Reaction: Thermostable DNA Polymerases, PCR technique and its variants, Quantitative Real-Time PCR, Site directed mutagenesis, Restriction and modifying enzymes Strategies and approaches to genome sequencing, Overview of Enzymatic DNA sequencing, NGS, AI-based assembly and annotation of DNA sequences.	8
4.	Creation of Recombinant Molecules and Libraries	Characteristics of plasmid and other cloning vectors, prokaryotic and eukaryotic expression vectors, Recombinant Protein purification by IMAC method. Preparation of Genomic, cDNA, EST and Large insert genomic libraries,	8
5.	Applications of Recombinant DNA Technology	Transgenic plants and animals, DNA vaccine, Gene therapy, PCR based diagnosis, Golden rice, Terminator technology, Safety guidelines of recombinant DNA research.	8

Learning Resources	
Text Books	***Reference Books***
Gene Manipulation 6th Ed 2021Twyman, Richard M; Old, R. W	**Molecular Cell Biology** Lodish, Harvey et al,., Freeman and Co., 2023
Recombinant DNA 2nd Ed. 2025 James D. Watson	

Gaps in the Syllabus (to meet Industry/Profession requirements)	*Nil*
Pos met through Gaps in the Syllabus	*Nil*
Topics beyond syllabus/Advanced topics/Design	*Nil*
Pos met through Topics beyond syllabus/Advanced topics/Design	*Nil*

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***			
	Continuous Internal Assessment	50%			
	Semester End Examination	50%			
	Continuous Internal Assessment	***% Distribution***			
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%			
	Assignment(s)	10%			
	Seminar before a Committee	10%			
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***
	Continuous Internal Assessment	√	√	√	√
	Semester End Examination	√	√	√	√

Indirect Assessment	

	Mapping Between Course Outcomes and Program Outcomes					
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	3	3	2
CO2	3	2	1	2	3	1
CO3	3	1	2	1	3	3
CO4	3	3	3	1	3	1

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures

CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26411
Course title	ENZYME AND BIOPROCESS TECHNOLOGY
Pre-requisite(s)	BT26403
Co-requisite	Nil
Credits	3
Class schedule per week	L: 3 T:0 P:0
Class	M.Sc
Semester / Level	II/4
Branch	Biotechnology
Name of Teacher	Dr. Ramesh Chandra

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	Understand the process of microbial growth and synthesis of bioproducts, methods of measurements of growth and mass balance of the bioprocess, kinetics of product formation
2	Aware about significance of enzyme catalysis, production of enzyme and stability related issues, media constituents, formulations and sterilization, types of sterilizes and role of filers on sterilization
3	Expand the knowledge on agitation of media, stirring mechanism, kinetics of oxygen supply, and requirement of power during the process
4	Identify the reactors applicability as per the process requirement, understand mode of reactor operation and significance of solid state fermentation

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Understand the growth kinetics, Monod equation and explain the role of various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process and sterilization
CO2	State the significance of application of process technology on enzyme production, enzyme kinetics, solve the mass balance of production process, learn the process of oxygen transfer rate, agitation systems
CO3	Collect the proficient knowledge of design of fermenter and operation of fermentation process, methods of translation of laboratory data to pilot scale process

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	Cell growth and bio-product formation kinetics	Growth patterns and kinetics in batch culture, quantification of cell growth, effect of environmental factors on microbial growth, kinetics of product formation, growth, non-growth associated products, yield concepts and mass balance.	8
2	Enzyme kinetics	Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, effect of pH, temperature, concentration of substrate on enzyme catalysis, stability of enzymes, methods of immobilization, immobilized enzyme reactors, diffusional limitations in immobilized enzyme systems, large scale enzyme production, case study for manufacture of commercial enzymes and applications.	8
3	Media and air sterilization	Importance of media on growth, introduction and the kinetics of death, batch and continuous sterilization of media, air sterilization, various type of sterilization equipments, sterilization of media by membrane filters.	8
4	Agitation and aeration	Types of impellors and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (K_La), measurement of K_La, power requirement for agitation in gaseous and non gaseous systems.	8
5	Bioreactor Selection and Design	Selection criteria for bioreactor, body construction of fermenter and its components, solid state and submerged fermentation, design aspects of bubble column bioreactor, air-lift fermenter, plug-flow and packed bed bioreactor, scaling up of bioreactor, Choosing the cultivation methods, Batch, fed-batch and continuous bioreactors.	8

Learning Resources

Text Books	*Reference Books*
1: Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR 2: Aiba and Humphary. Biochemical Engineering, Academic Press, New York 3: Doran, Bioprocess Engineering Principles, Academic Press, 2013. 4: Enzyme by Palmer (2001); Horwood publishing series	1: Bailey and Ollis, Biochemical Engineering Fundamentals, McGraw-Hill, 1986. 2: Lee, Biochemical Engineering, Prentice Hall, 1992

Gaps in the Syllabus (to meet Industry/Profession requirements)	Nil
Pos met through Gaps in the Syllabus	NA
Topics beyond syllabus/Advanced topics/Design	Nil
POs met through Topics beyond syllabus/Advanced topics/Design	NA

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					
Indirect Assessment						

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	2	3	-	2
CO2	1	1	3	2	3	2
CO3	3	2	-	2	3	3
No mapping = -, < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD5
CO2	CD1, CD2, CD5
CO3	CD1, CD2, CD5

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Ramesh Chandra

Course code	BT26413
Course title	BIOINFORMATICS
Pre-requisite(s)	NA
Co-requisite	NA
Credits	L: 3 T:0 P:0
Class schedule per week	3
Class	MSc
Semester / Level	II/04
Branch	Biotechnology
Name of Teacher	Dr. Koel Mukherjee

COURSE INFORMATION

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1	State and comprehend the fundamental concepts of database system and its architecture, importance of biological database in the current time. Extend comprehensive knowledge about data mining and Big data analysis and its complexity.
2	Gain knowledge about the techniques for molecular modelling and drug designing
3	Familiarize students with AI-driven approaches for structural biology and drug discovery.
4	Expose students to emerging applications of bioinformatics and artificial intelligence in biotechnology and biomedical research.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
1	Explain the theoretical knowledge of database system and algorithms. Analyze and discuss the knowledge of sequence alignment and phylogenetic tree plot
2	Develop the key skills of modern Bioinformatics techniques currently practiced in any pharmaceutical research and development unit.
3	Analyze biological sequences, structures, and large-scale datasets using appropriate bioinformatics and AI methodologies.
4	Evaluate the effectiveness and limitations of computational strategies for biotechnology and biomedical applications.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
I	Databases of Bioinformatics & Sequence Analysis	Database types and its architecture, Databases (Primary, Secondary and Specialized), Different database File Formats. Pairwise sequence alignment, Dynamic programming (Needleman-Wunsch and Smith Waterman) algorithm, Gap Penalty, Scoring matrices (PAM, BLOSUM), BLAST.	9
II	Phylogenetic Analysis	Phylogeny and Phylogenetic analysis, Substitution Models of evolution, Tree reconstruction methods (Distance based and character based), applications of evolutionary analysis in biological research.	7
III	Molecular Modeling and Docking	Classification of 3-D structures of proteins, Protein Structure Prediction, Homology modelling and validation. AI-driven protein structure prediction using AlphaFold, Molecular docking and its application in computer aided drug designing.	7
IV	Introduction to AI and ML	Introduction to Artificial Intelligence in biology. Fundamentals of machine learning, supervised and unsupervised learning, feature engineering and data pre-processing, regression and classification algorithms (Linear Regression, Decision Trees, Random Forests, Support Vector Machines).	8
V	Advanced Applications of AI in Bioinformatics and Biotechnology	Application to modern biomedical sector: omics and multi-omics data analysis, AI-driven drug discovery and development, ADMET prediction, protein engineering, precision medicine and critical analysis of recent research articles in Bioinformatics and Artificial Intelligence.	8

Learning Resources	
Text Books	***Reference Books***
1. Bioinformatics: Sequence and Genome Analysis, David W Mount, Cold Spring Harbor Laboratory Press, New York. 2. Lesk, A.M., Introduction to Bioinformatics, 6th Edition, Oxford University Press.	1. Guidebook on Molecular Modeling In Drug Design, J. G. Vinter, Mark Gardner (Editor), J. G. Vinter (Editor), CRC Press (May 1994) ISBN: 0849377722 2. Fundamental Concepts of Bioinformatics, Dan E Krane, Michael L Raymer, Benjamin-Cummings Pub Co (ISBN 0805346333) 3. Alpaydin, E., Introduction to Machine Learning, MIT Press.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Design of real-time industrial projects.
Pos met through Gaps in the Syllabus	***Nil***
Topics beyond syllabus/Advanced topics/Design	***Nil***
Pos met through Topics beyond syllabus/Advanced topics/Design	***Nil***

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	1	1	-
CO2	2	3	1	1	-	-
CO3	3	2	3	2	1	1
CO4	3	3	1	2	1	1

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD3, CD6
CO3	CD1, CD2, CD3
CO4	CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26415
Course title	Analytical Techniques in Biotechnology
Pre-requisite(s)	NA
Co-requisite	NA
Credits	L:3 T: 0 P:0
Class schedule per week	3
Class	MSc
Semester / Level	II / Fourth
Branch	Biotechnology
Name of Teacher	Dr. Manish Kumar

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	To impart fundamental knowledge of the principles, instrumentation, and applications of modern analytical techniques used in biotechnology
2.	To familiarize students with separation, characterization, and imaging techniques employed in biological and biochemical research
3.	To develop understanding of the operation, maintenance, and safe use of analytical instruments and associated data acquisition systems
4.	To introduce computational tools, chemometrics, and Artificial Intelligence/Machine Learning approaches for processing and interpretation of analytical data
5.	o enable students to select and apply appropriate analytical techniques for solving research problems in biotechnology and interdisciplinary domains

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Explain the principles, instrumentation, and applications of centrifugation, microscopy, electrophoretic, chromatographic, spectroscopic, and thermal analytical techniques used in biotechnology
CO2	Demonstrate knowledge of the operation, maintenance, safety considerations, and limitations of analytical instruments and associated data acquisition systems
CO3	Apply centrifugation, electrophoretic, chromatographic, spectroscopic, and thermal analysis techniques for the separation, identification, and characterization of biomolecules and biological samples
CO4	Analyze and interpret analytical data using chemometric methods and AI/ML-based tools for image processing, spectral analysis, pattern recognition, and biomolecular characterization
CO5	Evaluate the strengths and limitations of various analytical techniques and select appropriate methods for solving research problems in biotechnology and multidisciplinary applications

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	Centrifugation Techniques and Imaging	Principle, instrumentation and applications of steady-state sedimentation, density gradient centrifugation and ultracentrifugation. Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM). Artificial Intelligence (AI) applications in microscopy and automated image analysis for biological samples.	8
II	Electrokinetics and Electrophoretic Techniques	Electro-osmosis and electrophoresis, Helmholtz-Smoluchowski equation, zeta potential. Principles, design and applications of gel electrophoresis, SDS-PAGE, gradient gels, two-dimensional gel electrophoresis and isoelectric focusing. AI-assisted protein spot detection for proteomics applications.	8
III	Chromatographic Techniques	Principles, design and applications of column chromatography, partition chromatography, adsorption chromatography, affinity chromatography, ion exchange chromatography, gas chromatography and High-Performance Liquid Chromatography (HPLC). Computer-aided chromatographic data analysis, peak deconvolution and machine learning approaches for biomolecular identification and quantification	8
IV	Spectroscopy – I	Beer-Lambert law. Principles, instrumentation and applications of UV-Visible spectrophotometry, spectrofluorimetry (FRET), FTIR and NMR spectroscopy. Chemometrics and AI-based spectral data processing, multivariate analysis, pattern recognition and classification of biomolecules.	8
V	Spectroscopy – II and Thermal Analysis	Principles, instrumentation and applications of flame emission spectroscopy and atomic absorption spectroscopy with comparative studies. ICP-MS: principles, instrumentation and applications. Differential Scanning Calorimetry (DSC) and Thermogravimetric Analysis (TGA). Artificial Intelligence and machine learning approaches for spectral interpretation and predictive analytics in biotechnology research	8

Learning Resources	
Text Books	***Reference Books***
K. Wilson & K.H. Goulding, A biologist's guide to Principles and Techniques of Practical Biochemistry. Cambridge University Press, 1994	Willard and Merrit, Instrumental Methods and Analysis, CBS Publishers & Distributors; 7th edition (December 1, 2004)
	Ewing GW, Instrumental Methods of Chemical analysis. "McGraw-Hill Inc.

Gaps in the Syllabus (to meet Industry/Profession requirements)	1. Limited exposure to AI and Machine Learning tools for analytical data interpretation. 2. Limited coverage of chemometrics and computational analysis of spectral and chromatographic data
Pos met through Gaps in the Syllabus	PO1, PO3, PO4, PO6
Topics beyond syllabus/Advanced topics/Design	1. Artificial Intelligence and Machine Learning in biotechnology 2. Chemometrics and multivariate statistical analysis of spectral data 3. Multi-omics data integration and predictive analytics
Pos met through Topics beyond syllabus/Advanced topics/Design	PO1, PO2, PO3, PO4, PO6

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	2	3		
CO2	2	1	2	3	2	1
CO3	3	1	3	3	1	2
CO4	3	2	3	3	1	2
CO5	3	2	3	3	2	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	*Experts from Higher Technical Institutions*	*Internal Experts*

COURSE INFORMATION

Course code	BT26412
Course title	Professional Practice & Entrepreneurships
Pre-requisite(s)	Nil
Co-requisite	Nil
Credits	L: 0 T: 1 P:2
Class schedule per week	03
Class	M. Sc.
Semester / Level	II/04
Branch	Biotechnology
Name of Teacher	Dr. H. R. Singh

Course Objectives *This course aims to provide students with:*	
Sl No.	**Objectives**
1.	To develop professional ethics and workplace skills.
2.	To understand entrepreneurship and innovation concepts.
3.	To familiarize students with business planning and startup ecosystems.
4.	To enhance communication, leadership, and managerial abilities.
5.	To encourage entrepreneurial thinking among science graduates.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Demonstrate an understanding of professional ethics, workplace responsibilities, and sustainable professional practices.
CO2	Apply effective communication, leadership, teamwork, and managerial skills in professional and organizational settings.
CO3	Identify entrepreneurial opportunities and explain the concepts, characteristics, and functions of entrepreneurship and innovation.
CO4	Develop business plans by applying knowledge of market analysis, financial planning, resource management, and risk assessment.
CO5	Analyze the startup ecosystem, government support mechanisms, incubation facilities, and emerging entrepreneurial trends for establishing sustainable ventures.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
1	Professional Ethics and Workplace Practices	Meaning and importance of professional practice, Professional ethics and code of conduct, Integrity, accountability, and social responsibility, Intellectual property rights and plagiarism, Environmental and sustainability issues in professional practice. Ethical and responsible use of AI in professional practice and decision-making.	8
2	Communication and Leadership Skills	Professional communication and presentation skills, technical writing and report preparation, Teamwork and conflict management, Leadership styles and decision-making, Time management and workplace etiquette. Application of AI tools for communication, report writing, and leadership support.	8
3	Fundamentals of Entrepreneurship	Concept and characteristics of entrepreneurship, Types of entrepreneurs and entrepreneurial competencies, Entrepreneurship development in India, Innovation, creativity, and opportunity identification, Role of startups and MSMEs. AI-driven innovation and identification of entrepreneurial opportunities.	8
4	Business Planning and Management	Business idea generation and feasibility analysis, Market survey and market analysis, Business model and business plan preparation, Sources of finance and funding agencies, Marketing, operations, and risk management. Use of AI for market analysis, business planning, and financial forecasting.	8
5	Startup Ecosystem and Emerging Trends	Startup ecosystem in India, Government schemes: Startup India, Make in India, MSME support, Incubation centers and technology transfer, social entrepreneurship and sustainable enterprises, Case studies of successful entrepreneurs and startups. AI applications in startups, incubation, and emerging digital entrepreneurship ecosystems.	8

Learning Resources

Text Books	***Reference Books***
1. Khanka, S. S. Entrepreneurial Development. S. Chand Publishing, New Delhi. 2. Desai, V. Dynamics of Entrepreneurial Development and Management. Himalaya Publishing House, Mumbai. 3. Hisrich, R. D., Peters, M. P., and Shepherd, D. A. Entrepreneurship. McGraw-Hill Education. 4. Robbins, S. P. and Judge, T. A. Organizational Behavior. Pearson Education. **5.** Subramanian, R. Professional Ethics. Oxford University Press.	1. Kuratko, D. F. Entrepreneurship: Theory, Process, and Practice. Cengage Learning. 2. Drucker, P. F. Innovation and Entrepreneurship. Harper Business. 3. Bovee, C. L. and Thill, J. V. Business Communication Today. Pearson Education. 4. Government of India. Startup India: Action Plan and Policy Documents.

Gaps in the Syllabus (to meet Industry/Profession requirements)	***Nil***
Pos met through Gaps in the Syllabus	***Nil***
Topics beyond syllabus/Advanced topics/Design	***Nil***
Pos met through Topics beyond syllabus/Advanced topics/Design	***Nil***

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***			
	Continuous Internal Assessment	50%			
	Semester End Examination	50%			
	Continuous Internal Assessment	***% Distribution***			
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%			
	Assignment(s)	10%			
	Seminar before a Committee	10%			
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***
	Continuous Internal Assessment				
	Semester End Examination				

Indirect Assessment	

	Mapping Between Course Outcomes and Program Outcomes					
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	2	1	2
CO2	1	2	1	3	1	1
CO3	3	2	2	3	2	2
CO4	2	3	3	2	3	1

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD4, CD6
CO4	CD1, CD3, CD6

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26408
Course title	Enzyme and Bioprocess Technology Lab
Pre-requisite(s)	Nil
Co-requisite	Enzyme and Bioprocess Technology
Credits	1.5
Class schedule per week	L:0 T:0 P:3
Class	M.Sc
Semester / Level	II/4
Branch	Biotechnology
Name of Teacher	Dr. Ramesh Chandra

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	Understand the process of microbial growth and synthesis of bioproducts, methods of measurements of growth and mass balance of the bioprocess, kinetics of product formation
2.	Aware about significance of enzyme catalysis, production of enzyme at large scale and stability related issues, media constituents, formulations and sterilization, types of sterilizes and role of filers on sterilization
3.	Expand the knowledge on agitation of media, stirring mechanism, kinetics of oxygen supply, and requirement of power during the process
4.	Identify the reactors applicability as per the process requirement, understand mode of reactor operation and significance of solid state fermentation

Course Outcomes (COs)

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

CO	Course Outcomes
CO1	Understand the growth kinetics, Monod equation and explain the role of various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process and sterilization
CO2	State the significance of application of process technology on enzyme production, enzyme kinetics, solve the mass balance of production process, learn the process of oxygen transfer rate, agitation systems
CO3	Collect the proficient knowledge of design of fermenter and operation of fermentation process, methods of translation of laboratory data to pilot scale process

Syllabus

Experiments are based on theory course BE26502 Advanced bioprocess engineering.

List of experiments (minimum eight to be performed)

Experiment-1 To prepare standard plot of bacterial biomass

Experiment-2 To prepare standard plot of protein

Experiment-3 To prepare standard plot of ammonia

Experiment-4 To prepare standard plot of sugar

Experiment-5 Growth of Bacteria/Yeast and estimation of specific growth rate

Experiment-6 Immobilization of enzymes by entrapment

Experiment-7 Kinetic study of enzymes

Experiment-8 Medium optimization by monofactorial search method

Experiment-9 Medium optimization by using models/AI&ML tools

Experiment-10 Estimation of D value for sterilization of microbial culture

Experiment-11 Bioreactor parts and accessories and its operation

Learning Resources	
Text Books	***Reference Books***
1: Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR 2: Aiba and Humphary. Biochemical Engineering, Academic Press, New York 3: Doran, Bioprocess Engineering Principles, Academic Press, 2013. 4: Enzyme by Palmer (2001); Horwood publishing series	1: Bailey and Ollis, Biochemical Engineering Fundamentals, McGraw-Hill, 1986. 2: Lee, Biochemical Engineering, Prentice Hall, 1992

Gaps in the Syllabus (to meet Industry/Profession requirements)	***Nil***
Pos met through Gaps in the Syllabus	***Nil***
Topics beyond syllabus/Advanced topics/Design	***Nil***
Pos met through Topics beyond syllabus/Advanced topics/Design	***Nil***

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	60%				
	Semester End Examination	40%				
	Continuous Internal Assessment	***% Distribution***				
	Lab Record	30%				
	Experiment Viva	20%				
	Quiz	10%				
	Semester End Examination	***% Distribution***				
	Performance	30%				
	Quiz	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	-	2	3	-	2
CO2	1	1	3	2	3	2
CO3	3	2	-	2	3	2
No mapping = -, < 34% = 1, 34-66% = 2, > 66% = 3						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD3
CO2	CD1, CD3
CO3	CD1, CD3, CD5

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BE26410
Course title	Genomics & rDNA Technique lab
Pre-requisite(s)	Nil
Co-requisite	Nil
Credits	1.5
Class schedule per week	L: 0 T:0 P: 3
Class	MTech
Semester / Level	II
Branch	Biotechnology
Name of Teacher	Dr. Kunal Mukhopadhyay

Course Objectives
This course aims to provide students with:

Sl No.	Objectives
1	Explain the principles used to isolate nuclear and plasmid DNA & cellular RNA and to perform PCR techniques.
2	Can isolate DNA, RNA, plasmids, and perform gel electrophoresis
3	Can perform PCR, cDNA synthesis, RT-PCR, and Real-time PCR
4	Generating contextual and conditional knowledge of gene cloning for various applications

Course Outcomes (COs)
Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Understand the principles of isolation of biomolecules using molecular biology techniques.
CO2	Analyse the experimental data using AI to select suitable PCR technique for need-based applications
CO3	Evaluate vectors for cloning genes
CO4	Apply AI to examine function of cloned genes

Syllabus

Sl. No.	*Detailed Contents*	*No. of classes*
1	Demonstration of instruments used in Molecular Biology Laboratory	4
2	Preparation of DNase-Free and RNase-Free Glassware and Plasticware	4
3	Isolation of DNA from Plant Leaves	4
4	Quantification of DNA using NanoDrop Spectrophotometer	4
5	Agarose Gel Electrophoresis of DNA	4
6	Isolation of RNA from Plant Leaves	4
7	Quantification of RNA using NanoDrop Spectrophotometer	4
8	Denaturing Agarose Gel Electrophoresis of RNA	4
9	Media preparation and Growth of Bacteria for Isolation of Plasmid DNA	4
10	Isolation of Plasmid DNA using Alkaline Lysis Method	4
11	Agarose Gel Electrophoresis of Plasmid DNA	4
12	Primer Designing for PCR (Demonstration)	4
13	Polymerase Chain Reaction (PCR) and Agarose Gel Electrophoresis of amplified products	4
14	Real-Time Quantitative PCR (qPCR) (Demonstration)	4

Learning Resources	
Text Books	***Reference Books***
Michael R. Green and Joseph Sambrook 2012 4th Ed Molecular Cloning: A Laboratory Manual, Vols 1-3, Cold Spring Harbor Laboratory, 2016.	

Gaps in the Syllabus (to meet Industry/Profession requirements)	***Nil***
Pos met through Gaps in the Syllabus	***Nil***
Topics beyond syllabus/Advanced topics/Design	***Nil***
Pos met through Topics beyond syllabus/Advanced topics/Design	***Nil***

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***			
	Continuous Internal Assessment	50%			
	Semester End Examination	50%			
	Continuous Internal Assessment	***% Distribution***			
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%			
	Assignment(s)	10%			
	Seminar before a Committee	10%			
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***
	Continuous Internal Assessment	√	√	√	√
	Semester End Examination	√	V	√	√

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	3	3	3
CO2	3	2	1	2	3	2
CO3	3	1	2	1	3	2
CO4	3	3	3	1	3	1
CO5						

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD3
CO2	CD3
CO3	CD3
CO4	CD3

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26501
Course title	lmmunotechnology
Pre-requisite(s)	NA
Co-requisite	NA
Credits	L: 3 T: 0 P:0
Class schedule per week	03
Class	M. Sc.
Semester / Level	III/04
Branch	Biotechnology
Name of Teacher	Dr Shubha Rani Sharma

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	To recapitulate the previous knowledge of immunology and to establish thorough understanding of various structure & function at cellular and molecular level.
2.	To provide a thorough understanding of the various immunology concepts in study of cell biology and to study the different tools and techniques used to study the immunology at molecular level.
3.	To provide students with a deep insight about the immunological reactions with emphasis on the effector mechanisms, rationale behind the immunological interactions leading to successful reactions.
4.	To teach our students to have a concrete knowledge about immunology human system to study about the basis of the interaction as well as the genes involved in it.
5.	To acquire in-depth knowledge of the molecular events involved in immunological processes and their regulation. To provide wider and global perspective of techniques involved as well as the genetic basis of the immunological diseases and their cure, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	**Course Outcomes**
CO1	to apply knowledge of immunology in various cellular functions, inculcate a knowledge of various issues related to immunological reactions eg the application of and research involved in functioning of the different molecules and moieties in the reactions.
CO2	to design and analyze the experiments related with the different molecules involved in immunology and use of the various techniques in the immunology to study the kinetics and rationale behind each phenomenon.
CO3	to identify, formulate, and solve problems arisen due to the inefficient functioning of the various immunological phenomenon leading to various immunological diseases.
CO4	to use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a molecular cell biology research project, collect and analyze data, and interpret results

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
Module 1:	Introduction:	Brief history of Immunotechnology, immune system, components of immune system, Innate and adaptive immune system, cell-mediated and humoral immunity, external and internal barriers, phagocytosis. Antigen clearance mechanism. Role of artificial intelligence in advancing immunology & Artificial Immune Systems (AIS)	(8L)
Module 2:	The antigens & antibodies	Antigens & Antibodies, Types of Antibodies, Genetic basis of Antibody Diversity, Hybridoma technology. Catalytic Antibodies, Immunogenicity, MHC, Ag-Ab interaction, Precipitin curve, Immuno diffusion, Agglutination, effector mechanism & Cytokines, complement system. Protein Engineering and Antibody Discovery (AI)	(8L)
Module3:	Techniques in Immunotechnology	Blood groups: AB, Rh system, radial immunodiffusion, Ouchterlony double immunodiffusion, Immuno electrophoresis, Widal test, Radioimmunoassay: ELISA, Immuno fluorescence, comet assay, FACS. ELISPOT assay, immunofluorescence, Surface plasmon resonance, Biosensor assays for assessing ligand – receptor interaction, Staining techniques for live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications; Stem Cell Immunology.	(8L)
Module 4:	Immunological diseases	Hypersensitivity & Immunodeficiency, Autoimmunity and Transplantation immunology. Animal models of immunodeficiency, Diagnosis, therapeutic approaches. Early Diagnosis & Risk Prediction using AI	(8L)
Module5:	Vaccines & Production of Antibodies	Antibody engineering, antigen engineering, Rationale of vaccine design, types of vaccines (live, killed, attenuated, Sub unit vaccines; Recombinant DNA and protein-based vaccines, plant-based vaccines and reverse vaccinology; Peptide vaccines, conjugate vaccines), Passive Immunization; Rational Vaccine Design & Epitope Prediction with AI, Reactor system for Production of Polyclonal antibodies, antigen preparation and modification, adjuvants, dose and route of antigen administration, collection of sera, purification of antibodies.	(8L)

Learning Resources	
Text Books	***Reference Books***
1. Kuby J, Immunology, WH Freeman & Co., 2000. 2. Tizard, Immunology, fourth edition, Thomson Asia pvt. Ltd, 2004. 3. 3. Talwar G.P. and Gupta S.K., "A hand book of pratical and clinical immunology Vol I & II CBS Publications, 1992.	1. Textbook of Basic and Clinical Immunology Sudha Gangal 2. Immunology by Ivan M. Roitt

Gaps in the Syllabus (to meet Industry/Profession requirements)	Individual assignment, Theory (Quiz and End semester) examinations
Pos met through Gaps in the Syllabus	Design of real-time research projects.
Topics beyond syllabus/Advanced topics/Design	Design optimization for molecular cell biology projects.
Pos met through Topics beyond syllabus/Advanced topics/Design	PO1, PO2, PO3, PO4, PO5.

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
COs / POs & PSOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	1	1	–
CO2	3	3	2	3	3	–
CO3	3	3	2	2	2	–
CO4	3	3	2	2	2	2

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1,CD2, CD3, CD6
CO2	CD1, CD2, CD3,CD4, CD6
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2, CD3, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT 26503
Course title	Environmental Biotechnology
Pre-requisite(s)	Basics in Microbiology, Molecular biology, Bioanalytical techniques
Co-requisite	BT 26506 Environmental Biotechnology Lab
Credits	3
Class schedule per week	L: 3 T: P:
Class	MSc
Semester / Level	III/ 5th
Branch	Biotechnology
Name of Teacher	Dr. Shaswati Ghosh (Sachan)

Course Objectives
This course aims to provide students with:

Sl No.	Objectives
1	Details of the factors responsible for environmental pollution
2	Solutions for environmental problems and understand legal aspects related with environmental issues and protection
3	Selection of appropriate methods for the treatment of solid wastes and wastewater
4	Suitable bioremediation methods for the waste management
5	Exposure to significance of biofuels and organic farming

Course Outcomes (COs)
Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Identify the problems related to environment and be aware of the Environment Protection Acts and Legislations
CO2	Determine the different methods used for monitoring of pollution in environment and treatment of secondary wastewater
CO3	Apply appropriate techniques for management of different types of solid wastes
CO4	Design techniques for bioremediation processes and evaluate the role of advanced technologies in environmental clean up
CO5	Identify and evaluate the importance of biofuels/organic farming and explain the role of AI in organic farming

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	**Introduction**	Ecology, Natural resources, Types of pollution, Environmental Protection Acts and Legislations, Biodiversity and its conservation strategies, Environmental Planning for sustainable development	8
II	**Pollution monitoring and Wastewater Management**	Environmental monitoring & sampling, Modes of biological methods for wastewater treatment, aerobic and anaerobic methods, activated sludge digestion process	8
III	**Solid Waste Management**	Solid waste-types and characteristics. Effects of solid waste generation on quality of air, water and public health; Technical approach for solid waste management; Disposal of organic and medical waste; Plastic and E-waste management, Hazardous waste management	8
IV	**Bioremediation**	*In-situ* & *Ex-situ*, Microbial degradation and its mechanism, Bioaugmentation, Biosorption, Bioleaching, Phytoremediation, GMOs in waste management, Nano-bioremediation, Biosensors in pollution monitoring, AI-driven bioremediation of xenobiotics	8
V	**Biofuels and Organic farming**	Biomass as a source of energy, Liquid and gaseous biofuels, Microbial fuel cell, Biofertilizers, Biopesticides, Bio-Composting, Vermiculture, Application of AI in Organic farming	8

Learning Resources	
Text Books	***Reference Books***
Dash and Dash, Fundamentals of ecology, 3rd Ed., TMH Education, 2009	Odum, Fundamentals of Ecology, 5th Ed., Brooks/Cole, 2004
Scragg, A, H., Environmental Biotechnology (2nd Edition).: Oxford University Press. 2004	Environmental Biotechnology: Theory and Application, Second Edition Gareth M. Evans and Judith C. Furlong © 2011 John Wiley & Sons, Ltd. ISBN: 978-0-470-68418-4
	Metcalf and Reddy Inc et al, Wastewater Engineering: Treatment and Reuse, 4th Ed., McGrawHill Higher Education, 2002

Gaps in the Syllabus (to meet Industry/Profession requirements)	Nil
Pos met through Gaps in the Syllabus	Nil
Topics beyond syllabus/Advanced topics/Design	Nil
Pos met through Topics beyond syllabus/Advanced topics/Design	Nil

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	3	2	2
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	2	2	3	3	3	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26505
Course title	Concepts in Nanobiotechnology
Pre-requisite(s)	Nil
Co-requisite	Nil
Credits	L: 2 T:0 P:0
Class schedule per week	02
Class	M.Sc.
Semester / Level	III/05
Branch	Biotechnology
Name of Teacher	Dr. Sneha Singh

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1	Introduce the fundamental concepts of nanoscience and nanobiotechnology.
2	Familiarize students with important nanomaterials and their characterization techniques.
3	Explain the applications of nanobiotechnology in healthcare, diagnostics, and biotechnology.
4	Develop awareness of emerging trends, including AI applications, biosafety, and ethical aspects of nanobiotechnology.

Course Outcomes (COs)

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

CO	Course Outcomes
CO 1	Explain the fundamental principles, synthesis approaches, and properties of nanomaterials relevant to biological systems.
CO 2	Describe major nanomaterials and the basic techniques used for their characterization.
CO 3	Discuss the applications of nanobiotechnology in drug delivery, biosensing, bioimaging, and related biomedical fields.
CO 4	Evaluate emerging developments in nanobiotechnology, including AI-assisted research, biosafety concerns, and societal implications.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Introduction to Nanobiotechnology**	Nanoscience and nanotechnology: concepts and significance, Size-dependent properties of nanomaterials, Classification of nanomaterials, Top-down and bottom-up approaches, Biological/green synthesis of nanoparticles	06
2	**Nanomaterials and Concepts**	Fullerenes, Carbon nanotubes, Metal nanoparticles, Quantum dots and dendrimers, Biological nanomaterials, Self-assembly and molecular recognition	06
3	**Characterization of Nanomaterials**	Electron microscopy (SEM, TEM), Atomic Force Microscopy (AFM), X-ray Diffraction (XRD), UV–Visible and FTIR spectroscopy, Dynamic Light Scattering (DLS)	05
4	**Applications of Nanobiotechnology**	Drug delivery systems, Cancer nanotechnology, Biosensors and nanobiosensors, Bioimaging, Tissue engineering	06
5	**Emerging Trends and Societal Perspectives**	AI in Nanobiotechnology: Introduction to AI and machine learning, AI-assisted design of nanomaterials, AI applications in drug delivery and nanomedicine Biosafety and Ethics: Nanotoxicology, Environmental and health concerns, Ethical and societal aspects of nanotechnology	05

Learning Resources	
Text Books	***Reference Books***
1. Niemeyer, C. M., & Mirkin, C. A. (2004). Nanobiotechnology: Concepts, Applications and Perspectives. Wiley-VCH. 2. Poole, C. P., Jr., & Owens, F. J. (2003). Introduction to Nanotechnology. Wiley.	1. Goodsell, D. S. (2004). Bionanotechnology: Lessons from Nature. Wiley. 2. Bhushan, B. (Ed.). (2017). Springer Handbook of Nanotechnology (4th ed.). Springer. 3. Vamathevan, J., et al. (2019). Applications of machine learning in drug discovery and development. Nature Reviews Drug Discovery, 18, 463–477.

Gaps in the Syllabus (to meet Industry/Profession requirements)	***Nil***
Pos met through Gaps in the Syllabus	***NA***
Topics beyond syllabus/Advanced topics/Design	***NA***
Pos met through Topics beyond syllabus/Advanced topics/Design	***NA***

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO 5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	-	1	-	-
CO2	2	3	-	2	3	-
CO3	2	1	2	2	1	2
CO4	1	-	2	1	2	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD3, CD6, CD7
CO3	CD1, CD2, CD4, CD6
CO4	CD2, CD4, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***
		Dr. Sneha Singh

COURSE INFORMATION

Course code	BT26502
Course title	lmmunotechnology Lab
Pre-requisite(s)	Nil
Co-requisite	Basics of immunology
Credits	1.5
Class schedule per week	L:0 T:0 P:3
Class	MSc
Semester / Level	I/4th
Branch	Biotechnology
Name of Teacher	Dr. Shubha Rani sharma

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	To provide a thorough understanding of various Immunological phenomenon occurring in the body to fight the entry of the antigen.
2.	To provide a thorough understanding of diversity of the antibodies and the different antigen and antibody reactions used for diagnosis of the various diseases.
3.	To provide students with a deep insight about the different immunological diseases.
4.	To teach our students to have a concrete knowledge about the types of vaccines and how are they made.
5.	To acquire in-depth knowledge of immunology, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Apply knowledge of immunology, inculcate a knowledge of various issues related to immunology eg vaccines etc. and immunological techniques.
CO2	Design and conduct experiments, as well as to analyze and interpret data of different immunological methods. To identify, formulate, and solve problems arisen due to the inefficient functioning of the immune system.
CO3	Use the techniques, skills, and modern tools necessary for detection of the immunological diseases, design a immunology research project, collect and analyze data, and interpret results.
CO4	Demonstrate knowledge and understanding of the engineering principles and apply these to manage projects work a recognition of the need for and an ability to engage in life-long learning.
CO1	Apply knowledge of immunology, inculcate a knowledge of various issues related to immunology eg vaccines etc. and immunological techniques.

Syllabus

List of Experiments

Sl. No.	Experiment Name
1.	To detect the blood group of the given sample.
2.	To perform differential count (DLC) of given sample.
3.	To perform the Technique of Radial immunodiffusion
4.	To learn and perform the technique of Ouchterlony Double Diffusion Technique
5.	To perform the pregnancy test with the help of Pregnancy Kit
6.	To learn the technique of Immunoelectrophoresis
7.	To study the technique of Rocket Immunoelectrophoresis for determination of concentration of antigen in unknown sample
8.	To perform widal test for detection of typhoid.
9	To study the different immunoinformatics tools.
10.	To perform the sandwich Dot ELISA Test for antigen detection
11.	To perform Affinity chromatography for antibody purification.
12	To identify cells in a blood smear

Learning Resources	
Text Books	***Reference Books***
1. Immunology: Theoretical and practical concepts in Laboratory Medicine. Hannah D. Zane, Saunders; 1 edition (2001)	Clinical Immunology and Serology: A Laboratory Perspective By Christine Dorresteyn Stevens, F.A. Davis Company; 2nd Revised edition edition (2009)

Gaps in the Syllabus (to meet Industry/Profession requirements)	Nil
Pos met through Gaps in the Syllabus	Nil
Topics beyond syllabus/Advanced topics/Design	Nil
Pos met through Topics beyond syllabus/Advanced topics/Design	Nil

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	60%				
	Semester End Examination	40%				
	Continuous Internal Assessment	***% Distribution***				
	Quiz I	10%				
	Lab record	30%				
	Viva	20%				
	Semester End Examination	% Distribution				
	Lab experimental performance	30%				
	Quiz	10%				
	Semester End Examination	% Distribution				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	3	3	3
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	3	3	3	3	3	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD3
CO2	CD1, CD3
CO3	CD1, CD3
CO4	CD1, CD3
CO5	CD1, CD3

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT 26504
Course title	Environmental Biotechnology Lab
Pre-requisite(s)	BT 26404 Microbiology Lab
Co-requisite	
Credits	1.5
Class schedule per week	L: T: P: 3
Class	M Sc
Semester / Level	I/4th
Branch	Biotechnology
Name of Teacher	Dr. Shaswati Ghosh (Sachan)

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	Analytical skills for assessing water quality using physicochemical and biological parameters
2.	Training in advanced instrumental technique of ICP-OES for detection of heavy metals in environmental samples
3.	Exploration of microbial applications in environmental sustainability and waste management
4.	Skill development for screening beneficial microorganisms for industrial and agricultural applications
5.	Ability to execute oral and experimental skills necessary for effective communication of the course, the ability to think critically regarding a topic and the delivery of scientific principles to both scientists and non-scientists community

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	**Course Outcomes**
CO1	Assess water quality using key parameters such as BOD, COD, TDS
CO2	Perform microbiological analysis to assess potability of water samples
CO3	Analyze environmental samples (water/soil) for heavy metals using ICP-OES
CO4	Evaluate microbial potential for degradation, bioconversion of wastes and identify beneficial microorganisms for agriculture
CO5	Follow biosafety and laboratory protocols during experimental work, Develop experimental and analytical skills, Record, analyze, and interpret experimental data

Syllabus

List of Experiments

Sl. No.	Experiment Name
1.	To determine the amount of biological oxygen demand (BOD) of a water sample
2.	To determine the amount of chemical oxygen demand (COD) of a water sample
3.	To determine the amount of total dissolved solids of a water sample
4.	To determine coliforms for estimating the quality of a water sample
5.	To estimate heavy metals in water/soil by ICP-OES
6.	To isolate xenobiotic degrading bacteria by selective enrichment technique
7.	To screen bacteria with ability to convert waste to useful products
8.	To screen bacteria with biofertilizer potential

Learning Resources	
Text Books	***Reference Books***
1. James G. Cappuccino and Natalie Sharman: Microbiology: A laboratory Manual, 7th Edition, Dorling Kindersley (India) Pvt.Ltd., 2005	
2. Hach Water Analysis Handbook, 7th Edition, Hach Company USA, 2008; 2012	

Gaps in the Syllabus (to meet Industry/Profession requirements)	Nil
Pos met through Gaps in the Syllabus	Nil
Topics beyond syllabus/Advanced topics/Design	Nil
Pos met through Topics beyond syllabus/Advanced topics/Design	Nil

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	60%				
	Semester End Examination	40%				
	Continuous Internal Assessment	***% Distribution***				
	Quiz I	10%				
	Lab record	30%				
	Viva	20%				
	Semester End Examination	% Distribution				
	Lab experimental performance	30%				
	Quiz	10%				
	Semester End Examination	% Distribution				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment	✓	✓	✓	✓	✓
	Semester End Examination	✓	✓	✓	✓	✓

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	3	3	3	3
CO2	2	2	3	3	3	3
CO3	2	2	3	3	3	3
CO4	2	2	3	3	3	3
CO5	3	3	3	3	3	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD3
CO2	CD1, CD3
CO3	CD1, CD3
CO4	CD1, CD3
CO5	CD1, CD3

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26417
Course title	Genomics
Pre-requisite(s)	Nil
Co-requisite	Nil
Credits	L: 03 T: 00 P:00
Class schedule per week	03
Class	M. Sc.
Semester / Level	I/04
Branch	Biotechnology
Name of Teacher	Dr. D. M. Pandey

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	To understand about differences between prokaryotic and eukaryotic genomes
2.	To learn about techniques used in genomics, genome sequencing, annotation and database development
3.	To impart knowledge about the advances in structural and functional aspect of newly sequenced genome
4.	To use genomics in the crop improvement, drug discovery, valueadded crops as well as development of recombinant protein.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Explain and characterise about genome and can infer its evolutionary relations
CO2	Design the experiments on genome sequencing and analyse the generated biological data
CO3	Apply structural and functional genomics approaches on newly sequenced genomefor functional characterization of genes.
CO4	Pinpoint the strategies towards the use of genome data for crop improvement, development of drug, recombinant proteins or value-added crop.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
1	Genomic Evolution & Organization	Genetics to Genomics, Forward and revers genetics. Eukaryotic and prokaryotic genomes, Chromosome structure and function, Chromatin re-modeling/organization, Central dogma of molecular biology, role of AI in genome analysis	8
2	Genome Sequencing:	Overview of conventional and new sequencing technologies, NGS technologies, RNAseq, Genome annotation, Candidate gene discover and data mining, Transcription factor, Development of databases and their uses, comparative genomics, role of AI in genome sequencing	8
3	Techniques for Genomics	Restriction and modifying enzymes, Various blotting techniques, PCR techniques, RT-PCR, qPCR, Digital PCR, Site directed mutagenesis, Genomic and cDNA libraries, DNA microarray, Antisense RNA, RNA interference, TALEN, CRISPR-Cas9, AlphaGenome	8
4	Genome Initiatives	Structural and functional genomics, Advances in human genome, Advances in buffalo genome, Advances in arabidopsis genome, Advances in rice genome, Advances in wheat genome, Advances in tomato genome, Advances in sorghum genome, Advances in peanut genome, Advances in medicinal plant genomics , role of AI in genome initiatives	8
5	Application of Genomics	Genomics in gene function analysis, Genomics in plant andanimal breeding and improvement, Genomics in drug discovery, Genomics in valued added crops, Genomics in recombinant protein, application of AI in genomics and gene function analysis	8

Learning Resources	
Text Books	***Reference Books***
1. Principles of Genome analysis and Genomics, 3rd Edition, By S. B. Primrose and R. L. Twyman, Blackwell publishing (2003), ISBN: 1405101202 2. Bioinformatics and Functional Genomics, 3rd Edition, By Jonathan Pevsner, Wiley-Blackwell (2015), ISBN: 978-1-118-58178-0. 3. Advances in Genomics: Methods and application (Editor: Vijay Singh). Springer. DOI https://doi.org/10.1007/978-981-97-3169-5. ISBN978-981-97-3168-8. Published on 01 August 2024	1. Principles and Practices of Plant Genomics (Volume 3), By Chittaranjan Kole and Albert G. Abbott. CRC Press (2017): ISBN 9781138116498 2. Genome Analysis: Current Procedures and Applications by Maria S. Poptsova. CaisterAcademic Press (2014) ISBN: 978-1-908230-29-4.

Gaps in the Syllabus (to meet Industry/Profession requirements)	Nil
Pos met through Gaps in the Syllabus	Nil
Topics beyond syllabus/Advanced topics/Design	Nil
Pos met through Topics beyond syllabus/Advanced topics/Design	Nil

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***			
	Continuous Internal Assessment	50%			
	Semester End Examination	50%			
	Continuous Internal Assessment	***% Distribution***			
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%			
	Assignment(s)	10%			
	Seminar before a Committee	10%			
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***
	Continuous Internal Assessment				
	Semester End Examination				

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	2	1	1	2
CO2	1	2	1	3	1	1
CO3	3	2	2	3	2	3
CO4	2	3	3	2	3	1

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD4, CD6
CO4	CD1, CD3, CD6

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26419
Course title	INDUSTRIAL BIOTECHNOLOGY
Pre-requisite(s)	Nil
Co-requisite	Nil
Credits	L: 3 T: 0 P: 0
Class schedule per week	3
Class	M Sc
Semester / Level	Level: I/04
Branch	Biotechnology
Name of Teacher	Dr. V. K. Nigam

Course Objectives ***This course aims to provide students with:***	
Sl No.	**Objectives**
1.	To know about principle of growth, techniques used for enhancing the yield and role of various factors on the growth of biological strains, significance of medium constituents on production process in liquid cultivation
2.	To design criteria for fermenter and operation of bioreactor, solid state fermentation and calculation of yield
3.	To learn the processes of primary and secondary metabolites production with case study, production of enzymes and therapeutics from biological systems
4.	To gain knowledge about the application of living systems for energy production, in bioremediation and biotransformation with certain case study

Course Outcomes (COs) ***Upon successful completion of the course, students will be able to***	
CO	**Course Outcomes**
CO1	Explain the growth kinetics, Monod equation and various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process
CO2	Analyse the production process and regulatory mechanism of Primary metabolites
CO3	Evaluate the production process and regulatory mechanism of Secondary metabolites
CO4	Assess and optimize living systems in the energy production, utilization of waste to commercially important compounds and bioremediation process

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	**Technology of Microbial growth and Maintenance**	Principles of Microbial growth, Methods to increase yield of microbes, Strain preservation, maintenance and improvement, Microbial culture selection for high yield potential, Physico-chemical parameters for microbial growth	**8**
2	**Bioreactor/ Fermenter**	Types & operation of Bioreactors, Introduction to Batch, Fed-batch and Continuous culture systems, Limitations of bioreactors, Stages of fermentation processes, Media design for fermentation processes, Solid substrate fermentation, advantages & disadvantages of solid substrate & liquid fermentations	**8**
3	**Production of Primary and Secondary Metabolites**	A brief outline of processes for the production of some commercially important primary metabolites (e.g. citric acid, lactic acid, acetic acid etc., glutamic acid, aspartic acid etc.,) and alcohols (ethanol, butanol), Production processes for various classes of secondary metabolites such as beta-lactams (penicillin, cephalosporin etc.), aminoglycosides (streptomycin) macrolides (erythromycin) etc	**8**
4	**Production of Enzymes and other Bioproducts**	Production of industrial enzymes such as proteases, amylases, lipases, Production of biopesticides, biofertilisers, biopreservatives (Nisin), Single cell protein, Production of recombinant proteins with therapeutic and diagnostic applications, Production of vaccines and monoclonal antibodies, Products of bioproducts from plant and animal cell culture	**8**
5	**Bioconversions and Bioremediation**	Biomining and bioleaching of ores, Ethanol, methane and Hydrogen from biomass, Production of Biodiesel, Algal Biofuel, Bioremediation of oil spills, Wastewater treatment, Removal of heavy Metals, Microbial degradation of pesticides and aromatics compound	**8**

Learning Resources	
Text Books	Reference Books
1. Industrial Biotechnology, Isha Book, India (2006) 2. Biotechnology for Agro-Industrial Residues Utilisation, Springer, Netherland (2009) 3. Basic Industrial Biotechnology, New Age International Pvt Ltd, India (2012)	1. Industrial Biotechnology: Sustainable Production and Bioresource Utilization, CRC Presss, Taylor and Francis (2017) 2. Industrial Biotechnology: Microorganisms, John Wiley and Sons (2017)

Gaps in the Syllabus (to meet Industry/Profession requirements)	**Nil**
POs met through Gaps in the Syllabus	**Nil**
Topics beyond syllabus/Advanced topics/Design	**Nil**
POs met through Topics beyond syllabus/Advanced topics/Design	**Nil**

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	**50%**				
	Semester End Examination	**50%**				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	**30%**				
	Assignment(s)	**10%**				
	Seminar before a Committee	**10%**				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	
	Continuous Internal Assessment	**1**	**2**			
	Semester End Examination	**1**	**2**	**3**	**4**	

Indirect Assessment	**Student Feedback on Faculty**
	Student Feedback on Course Outcome

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**2**	**2**	**-**	**3**	**2**
CO2	**3**	**-**	**1**	**3**	**-**	**2**
CO3	**3**	**1**	**2**	**1**	**2**	**2**
CO4	**3**	**2**	**2**	**2**	**2**	**3**

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	**CD1,CD2,CD6**
CO2	**CD1,CD2, CD6**
CO3	**CD1, CD2,CD5,CD6**
CO4	**CD1,CD2,CD5,CD6, CD7**
CO5	**CD1,CD2,CD6**

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT 26421
Course title	MOLECULAR PLANT PHYSIOLOGY
Pre-requisite(s)	Science Graduate
Co-requisite	None
Credits	3
Class schedule per week	L: 3 T: 0 P:0
Class	MSc
Semester / Level	1st/ 4
Branch	Biotechnology
Name of Teacher	Dr. Sheela Chandra

Course Objectives
This course aims to provide students with:

Sl No.	Objectives
1.	To understand the molecular mechanisms of photosynthesis and carbon fixation pathways.
2.	To study energy metabolism and photorespiratory processes in plants.
3.	To understand light-mediated plant development and photoreceptor signalling.
4.	To study plant responses to different phytohormone, signalling pathways and biotic and abiotic stresses responses at molecular level.
5.	To introduce AI applications in plant biology and data analysis.

Course Outcomes (COs)
Upon successful completion of the course, students will be able to

CO	Course Outcomes
CO1	Explain light reactions and analyze different carbon fixation pathways.
CO2	Interpret respiratory pathways and their role in energy production.
CO3	Explain photoreceptor functions and regulation of plant growth responses.
CO4	Analyse phytohormone signalling, gene expression, cross talk and stress response mechanisms with adaptive strategies in plants.
CO5	Apply AI tools for analysis of biological data and plant systems.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
1.	Photosynthesis	Anatomy of chloroplasts, photosynthetic pigments, Structure of photosystems I and II and their coding genes, Molecular oxygen evolving complex, Photolysis of water; mechanisms of electron transport; Calvin cycle and its light/dark regulation. RuBisCO activities, C3, C4 and CAM pathways	8
2.	Photorespiration and Respiration	Photorespiration, Gross and net photosynthesis, Glycolysis, Citric acid cycle; Electron transport and ATP synthesis; Pentose phosphate pathway, Mitochondrial ATP synthase, Engineering or genetic modification of photorespiration	8
3.	Photomorphogenesis	Molecular structure of phytochrome, Photoconversion, Nuclear translocation of Pfr and modification of gene expression, Family of PHY genes and multiplicity of responses. Structure and function of Cryptochromes. Photoperiodism and biological clocks.	8
4.	Plant Hormones & Stress Physiology	Overview about various plant hormones, Molecular mechanism of plant hormones action, Hormone receptors and signal transduction, Phytohormone signalling in plant defense mechanism, Biotic and Abiotic stress responses in plants, Characteristic features of stress responsive genes, Physiological & Molecular responses to various stress perception, expression of regulatory genes and significance of gene products. Development of stress resistance plant.	8
5.	AI Applications in Plant Systems	Introduction to AI concepts, applications in plant sciences including phenotyping, stress and disease detection, gene expression analysis, case studies and overview of AI-based tools.	8

Learning Resources	
Text Books	***Reference Books***
Plant Physiology, 5th Edition by Lincoln Taiz and Eduardo Zeiger, Sinauer Associate. (2010). ISBN: 978-0878938667	The Molecular Life of Plants by Russell L. Jones, Helen Ougham, Howard Thomas, Susan Waaland (2012) Wiley-Blackwell. ISBN: 978-0-470-87011-2
Plant Physiology, 4th Edition, by Salisbury F. B. and Ross C. W. (2004), Wadsworth Publisher, ISBN: 9788131501658, 8131501655	Plant Hormones under Challenging Environmental Factors by Ahammed, Golam Jalal, Yu, Jing-Quan (2016) ISBN 978-94-017-7758-2
Bioinformatics: Sequence and Genome Analysis-David W Mount	Artificial Intelligence in Drug discovery, Edited by Nathan Brown

Gaps in the Syllabus (to meet Industry/Profession requirements)	Nil
Pos met through Gaps in the Syllabus	Nil
Topics beyond syllabus/Advanced topics/Design	Nil
Pos met through Topics beyond syllabus/Advanced topics/Design	Nil

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	2	2	1	2	1
CO2	1	2	2	2	2	2
CO3	2	3	3	2	3	2
CO4	3	3	3	3	3	3
CO5	3	2	2	3	3	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD4, CD5
CO2	CD1, CD2, CD3, CD4, CD5
CO3	CD1, CD2, CD3, CD4, CD6
CO4	CD1, CD2, CD3, CD4, CD5, CD6
CO5	CD1, CD2, CD3, CD5, CD6

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26423
Course title	Biosignal Acquisition System
Pre-requisite(s)	NA
Co-requisite	NA
Credits	L:3 T: 0 P:0
Class schedule per week	3
Class	MSc
Semester / Level	II / Fourth
Branch	Biotechnology
Name of Teacher	Dr. Rakesh Kumar Sinha

Course Objectives *This course aims to provide students with:*	
Sl No.	**Objectives**
1.	Understand the principles of biomedical instrumentation systems and the challenges associated with measurement in living systems.
2.	Explain the characteristics, acquisition, and conditioning of biomedical signals using sensors, electrodes, and transducers.
3.	Apply concepts of amplification, filtering, digitization, and data acquisition for biomedical signal processing.
4.	Describe the principles and applications of biotelemetry, wearable devices, and intelligent healthcare systems.
5.	Introduce Artificial Intelligence and Machine Learning techniques for analysis, classification, and decision support using biomedical data

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	**Course Outcomes**
CO1	Explain the principles of man-instrumentation systems, biometrics, and safety considerations involved in measuring physiological parameters
CO2	Describe various biomedical signals, electrodes, sensors, transducers, and methods for minimizing noise and recording artifacts.
CO3	Apply the principles of bioelectric amplifiers, filters, digitization, and data acquisition systems for biomedical signal processing.
CO4	Analyze the operation and applications of biotelemetry, wearable devices, and intelligent healthcare systems for remote patient monitoring.
CO5	Utilize basic Artificial Intelligence and Machine Learning techniques for feature extraction, classification, and decision support in biomedical applications.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
I	Man-machine Instrumentation System	Category and factors in measurement, biometrics, problems encountered in measuring a living system, Electrical safety considerations	8
II	Signals and Noise	Types of bio-signals and its sources, Electrodes for bio-physiological sensing, Transducers and other sensors, Recording problems and its remedy	8
III	Signal Conditioning and Digitisation	Different types of amplifiers and their principles of operation, Types of filters and their applications. Types of recorders, analog and digital filters, Concept of analog to digital conversion	8
IV	Biotelemetry and Intelligent Healthcare Systems	Electrophysiological telemetry, Radio telemetry system, Portable telemetry system, Land-line telemetry system, Internet of Medical Things (IoMT) and remote patient monitoring	8
V	Artificial Intelligence in Biomedical Instrumentation	Introduction to Artificial Intelligence and Machine Learning, Biomedical data preprocessing and feature extraction, Pattern recognition and classification of biosignals.	8

Learning Resources	
Text Books	***Reference Books***
J. J. Kar and J. M. Brown. Introduction to Biomedical Equipment Technology, 4th edition, Pearson India Education Services Pvt. Ltd., Noida, 2016	A. C. Guyton. Textbook of Medical Physiology, 8th edition, Prism Indian Publication, Bangalore, 1991
R. S. Khandpur. Handbook for Biomedical instrumentation, 3rd edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2014	D. C. Reddy. Biomedical Signal Processing: Principles and Techniques, Tata McGraw-Hill Education, 2005
L. Cromwell et al. Biomedical Instrumentation and Measurement, 2nd edition, Prentice-Hall, 2001	W. J. Tompkins. Biomedical Digital Signal Processing, Prentice-Hall, 1993

Gaps in the Syllabus (to meet Industry/Profession requirements)	• Need for practical understanding of modern biosensors and artifact reduction technique. • Intelligent decision-making tools for biomedical data interpretation.
Pos met through Gaps in the Syllabus	PO1, PO2, PO5
Topics beyond syllabus/Advanced topics/Design	• Advanced biosensors, artifact removal and signal conditioning techniques • Digital filtering, data acquisition systems, computer-assisted signal processing • AI-enabled decision support systems
Pos met through Topics beyond syllabus/Advanced topics/Design	PO1, PO2, PO3, PO4, PO5, PO6

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	2	3	2	1
CO2	2	1	2	3	1	1
CO3	3	2	2	3	2	1
CO4	2	2	3	3	2	2
CO5	3	3	3	3	2	3

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CO3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD3, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26425
Course title	Proteomics
Pre-requisite(s)	Nil
Co-requisite	Nil
Credits	L: 3 T: 0 P:0
Class schedule per week	03
Class	M. Sc.
Semester / Level	II/04
Branch	Biotechnology
Name of Teacher	Dr. Dev Mani Pandey

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	To study the primary, secondary, tertiary and quaternary structures of protein, translation and post translational modifications, protein folding and its role in attaining the most stable structure
2.	To know about characterization of protein, tools and techniques used for the determination of abundant protein in particular tissue
3.	To obtain information about atomic mass, amino acid sequence and basic physical and chemical properties of protein
4.	To gain knowledge about the production of industrially important proteins and enzymes, designing new proteins with functions of interest and use of proteomics database.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Know the proteomics basics and its structural and functional characterization.
CO2	Know the techniques used in protein separation, quantification and subsequent analysis
CO3	Demonstrate about various techniques used in secondary and tertiary protein structure determination as well as their applications
CO4	Use tools towards analysing quantitative proteomic data and their uses in biology, clinical and drug discovery research as well as designing novel proteins.

Syllabus

Module No.	*Module name*	*Detailed Contents*	*No. of Lecture*
1	Protein Basics:	Proteomics basics, Forces that determine protein structure and physicochemical properties, Mechanisms of protein folding, Molten globule structure, Characterization of folding pathways, AI in folding pathways characterization	8
2	Protein isolation and profiling:	Method for protein isolation and purification, Profiling by Native-PAGE, SDS-PAGE, 2-D/IEF SDS-PAGE, staining and de-staining, imaging and analysis of 1-D and 2-D gels, AI in protein profiling	8
3	Protein characterization:	Protein sequencing using various methods, Protein identification by mass spectrometry, Determination of post translation modification, Proteomics tools and databases, Thermal, enzymatic, physical, pressure, solvents, interactions effect on protein, Application of DSC, Protein denaturation, aggregation and gelation. Role of AI in protein characterization.	8
4	Protein structure:	Background and basic principles of various spectroscopic techniques used for protein structure determination, Absorption and fluorescence, Circular dichroism, FT-Raman, FT-IR, NMR, Protein crystallization and X-ray crystallography, MALLS, AI in protein structure analysis	8
5	Development of novel proteins**:**	Basic concepts for design of a new protein, Site directed mutagenesis for specific protein function, Specific examples of novel engineered proteins, AI in developing a novel proteins	8

Learning Resources	
Text Books	***Reference Books***
1. Introduction to Protein Structure (2012). Carl, Branden and Tooze, John (Editors). Garland Publishing, New York. https://doi.org/10.1201/9781136969898. eBook ISBN9780429062094. 2. Protein Structure-Function Relationships in Food (1999). Yada, R. Y.; Jackman, R. L.; Smith, J. L. (Editors). Springer New York, NY. DOI https://doi.org/10.1007/978-1-4615-2670-4. ISBN 978-0-7514-0186-8 **3.** Proteomics Data Analysis (July 2021) Cecconi D (Editor). https://doi.org/10.1007/978-1-0716-1641-3. Huma.na New York, NY. ISBN 978-1-0716-1640-6.	1. Spectroscopy of Biological Systems (1986) Clark, R. J. H and Hester, R. E. (Editors) Chichester, New York. ISBN : 0471909785. 2. Food Proteins: Properties and Characterization (1996) Nakai, S. and Modler, H. W. (Editors) VCH Publishers, New York. ISBN: 978-0-471-18614-4

Gaps in the Syllabus (to meet Industry/Profession requirements)	Nil
Pos met through Gaps in the Syllabus	Nil
Topics beyond syllabus/Advanced topics/Design	Nil
Pos met through Topics beyond syllabus/Advanced topics/Design	Nil

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	1	3	3	1	2
CO2	1	1	3	3	1	3
CO3	2	1	3	3	1	1
CO4	2	2	3	2	2	2

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3, CD4
CO3	CD1, CD2, CD3, CD4, CD6
CO4	CD1, CD3, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26427
Course title	Biomedical Instrumentation
Pre-requisite(s)	NA
Co-requisite	NA
Credits	L: 3 T: 0 P:0
Class schedule per week	3
Class	MSc
Semester / Level	II / Fourth
Branch	Biotechnology
Name of Teacher	Dr. Yogender Aggarwal

Course Objectives

This course aims to provide students with:

Sl No.	Objectives
1.	To impart interdisciplinary knowledge of biomedical instrumentation and physiological signal acquisition systems used in diagnosis and patient monitoring.
2.	To develop an understanding of the principles, operation, and clinical applications of cardiopulmonary, therapeutic, and surgical devices employed in healthcare.
3.	To familiarize students with the fundamentals of artificial intelligence and machine learning techniques for biosignal processing and intelligent healthcare systems.
4.	To provide knowledge of safety, performance evaluation, and ethical considerations associated with biomedical instruments and AI-assisted diagnostic systems

Course Outcomes (COs)

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

CO	Course Outcomes
CO1	Explain the principles, instrumentation, and clinical applications of bioelectric recording systems.
CO2	Understand the operation and performance characteristics of cardiopulmonary devices used for physiological monitoring and respiratory support.
CO3	Examine the principles and therapeutic applications of biomedical devices used in therapy and surgery.
CO4	Apply the fundamentals of artificial intelligence and machine learning for biosignal preprocessing, feature extraction, AI-assisted diagnosis, and evaluation of intelligent healthcare systems while considering ethical and performance aspects.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
I	Bioelectric Recorder	Factors in making measurement, Electrocardiography (ECG), Electromyography (EMG), electroencephalography (EEG), evoked potentials analysis, electroretinography (ERG), Electro-Oculography (EOG).	8
II	Cardiopulmonary Devices	Holter recorder, patient monitoring system, phonocardiography, blood pressure measurement, pulse plethysmography, Blood flow and cardiac output measurement, Ventilators, Anesthesia machine, Capnograph, Pulmonary function analyzers, Pneumotachometers.	8
III	Therapeutic Devices	Pacemakers, Defibrillators, Physiotherapeutic diathermies, nerve and muscle stimulators, electroshock therapy, medical linear accelerator, Co60 Machine.	8
IV	Surgical Devices	Surgical diathermy, Heart lung machine, extra corporeal membrane oxygenator, intra-aortic balloon pump, surgical laparoscopy, lithotripsy, Sterilization equipment.	8
V	Artificial Intelligence in Biosignal Processing	Introduction to Artificial Intelligence and Machine Learning in Healthcare; Biosignal preprocessing and feature extraction; AI-assisted diagnosis and patient monitoring; Performance evaluation metrics; Ethical considerations and challenges in AI-based healthcare systems	8

Learning Resources	
Text Books	***Reference Books***
R. S. Khandpur. Handbook for Biomedical instrumentation, 3rd edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2014	A. C. Guyton. Textbook of Medical Physiology, 8th edition, Prism Indian Publication, Bangalore, 1991
J. G. Webstar. Medical instrumentation, Application & Design, 4th edition, Wiley Student Edition, New Delhi, 2009	J. D. Bronzino. Biomedical Engineering and Instrumentation, Basic Concepts and Applications, 1st Edison, PWS Publishers, Boston, 1986
J. J. Kar and J. M. Brown. Introduction to Biomedical Equipment Technology, 4th edition, Pearson India Education Services Pvt. Ltd., Noida, 2016	

Gaps in the Syllabus (to meet Industry/Profession requirements)	• Limited exposure to AI-based biosignal analysis and intelligent diagnostics. • Lack of biomedical signal processing software and computational tools

	• Limited exposure to advanced imaging and data analytics techniques
Pos met through Gaps in the Syllabus	PO1, PO3, PO4
Topics beyond syllabus/Advanced topics/Design	1. Lecture on human-computer interaction 2. Lecture on specialized imaging devices
Pos met through Topics beyond syllabus/Advanced topics/Design	PO1, PO3, PO4, PO5, PO6

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
COs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1	–	2	3	–	–
CO2	2	–	2	3	1	–
CO3	2	–	3	2	2	1
CO4	3	1	3	3	2	2

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD3, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BE26429
Course title	Molecular Genetics & Pharmacogenomics
Pre-requisite(s)	Nil
Co-requisite	Nil
Credits	3
Class schedule per week	L:3 T:0 P:0
Class	M.Sc
Semester / Level	III/5
Branch	Biotechnology
Name of Teacher	**Dr. Ramesh Chandra**

Course Objectives

This course aims to provide students to

Sl No.	Objectives
1	Learn the aspects of molecular genetics pharmacogenetics & pharmacogenomics
2	Gain comprehensive knowledge about pharmacogenetic and pharmacogenomic aspects of multi drug resistance associated protein, organic anion transporter peptide family media constituents. They will also learn about pharmacogenomics of asthma, chemo therapeutic agents in cancer, alcoholism and neurodegenerative diseases.
3	Identify, locate, analyse frequencies and SNPs
4	Process comparative genomic data, proteome and related genetic information.

Course Outcomes (COs)

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

CO	Course Outcomes
CO1	Discuss various aspects of molecular genetics pharmacogenetics & pharmacogenomics
CO2	Interpret comprehensive knowledge about pharmacogenetic and pharmacogenomic aspects of multi drug resistance associated protein, organic anion transporter peptide family media constituents, asthma, chemo therapeutic agents in cancer, alcoholism and neurodegenerative diseases
CO3	Distinguish SNPs as genetic marker
CO4	Analyse comparative genomic data, proteome and genetic information.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
1	Genome & its analysis	Organisation of eukaryotic and prokaryotic genome, Methods of gene analysis, Comparative genome analysis, Analysis of proteome, concepts of genetics, pharmacogenetics and pharmacogenomics.	8
2	Single Nucleotide Polymorphism	SNPs as genetic marker, Identification, location, frequency and analysis of SNPs; SNPs based pharmacogenomic markers.	8
3	Pharmacogenomics and Drug design	Role of pharmacogenomics in drug design, In silico design of small molecules, Automated drug design methods, Structure based drug design methods, Ligand based drug design methods	8
4	Drug Transporters	Pharmacogenomics of human P- glycol protein, drug transporters, Multi drug resistance associated protein, Organic anion transporter peptide family.	8
5	Pharmacogenomics of diseases	Pharmacogenomics aspects in Asthma, Alcoholism, Neurodegenerative diseases and Cancer (Chemo therapeutic agents in cancer).	8

Learning Resources	
Text Books	***Reference Books***
1. Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, Oliver Kayser, Rainer H. Miller, Wiley Interscience, 2004 2. Pharmaceutical Biotechnology by S.P. Vyas, V.K.Dixit, 1st ed,CBS Publishers & Distributors, New Delhi, 1998 3. Pharmaceutical Biotechnology by Daan J.A. Crommilin & Robert D. Sindelar (edts.) Routledge, Taylor & Francis group, London 2002	Pharmacogenomics: The search of Individual Therapies, Julio Licinio and Ma-li Wong, Wiley-Blackwell; 2002

Gaps in the Syllabus (to meet Industry/Profession requirements)	Nil
Pos met through Gaps in the Syllabus	Nil
Topics beyond syllabus/Advanced topics/Design	Nil
Pos met through Topics beyond syllabus/Advanced topics/Design	Nil

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1	1	-	2
CO2	3	2	2	-	1	2
CO3	3	2	3	-	1	2
CO4	3	2	3	1	1	3

No mapping = - , < 34% = 1, 34-66% = 2, > 66% = 3

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2
CO2	CD1, CD2, CD4
CO3	CD1, CD2, CD4
CO4	CD1, CD2, CD4

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***

COURSE INFORMATION

Course code	BT26431
Course title	Systems Biology
Pre-requisite(s)	Fundamentals of Cell Biology, Elementary Mathematics
Co-requisite	Bioinformatics
Credits	3
Class schedule per week	L: 3 T:0 P:0
Class	M.Sc.
Semester / Level	2nd
Branch	Biotechnology
Name of Teacher	Dr. Anjana Dwivedi

Course Objectives *This course aims to provide students with:*	
Sl No.	Objectives
1.	Introduce students to the fundamental principles, concepts, and interdisciplinary nature of Systems Biology, emphasizing the integration of biological, mathematical, and computational sciences.
2.	Develop an understanding of the structure, organization, and dynamics of biological networks, including gene regulatory, metabolic, signaling, and protein interaction networks.
3.	Familiarize students with quantitative and computational approaches used for modeling, simulation, and analysis of complex biological systems.
4.	Enable students to interpret and integrate high-throughput biological data generated through genomics, transcriptomics, proteomics, and metabolomics technologies.
5.	Expose students to contemporary applications of Systems Biology in biotechnology, systems medicine, drug discovery, synthetic biology, precision healthcare, and artificial intelligence-driven biological research.

Course Outcomes (COs) *Upon successful completion of the course, students will be able to*	
CO	Course Outcomes
CO1	Explain the principles and scope of systems biology and network-based thinking in biological sciences.
CO2	Analyze biological systems using gene regulatory, signaling, metabolic, and protein interaction networks
CO3	Apply mathematical and computational approaches for modeling biological processes.
CO4	Interpret multi-omics datasets using systems biology frameworks.
CO5	Evaluate applications of systems biology in biotechnology, medicine, and synthetic biology.

Syllabus

Module No.	***Module name***	***Detailed Contents***	***No. of Lecture***
1.	Introduction to Systems Biology	Historical development of Systems Biology, reductionist versus holistic approaches, emergent properties of biological systems, levels of biological organization, components of biological systems, biological complexity and robustness, systems thinking in biotechnology, overview of biological networks.	8
2.	Biological Networks and Network Analysis	Fundamentals of network biology, graph theory concepts in biology, gene regulatory networks, protein-protein interaction networks, metabolic networks, signal transduction networks, network motifs and modules, network topology and dynamics, introduction to Cytoscape and biological network databases.	8
3.	Mathematical Modeling of Biological Systems	Concepts of biological modeling, deterministic and stochastic models, ordinary differential equations in biology, mass action kinetics, Michaelis-Menten kinetics, Hill equations and cooperativity, dynamic behavior of biological systems, feedback loops and oscillatory systems, model validation and parameter estimation.	8
4.	Omics and Data Integration in Systems Biology	Genomics and transcriptomics, proteomics and metabolomics, multi-omics approaches, biological databases and repositories, data preprocessing and normalization, dimensionality reduction techniques, biological pathway analysis, machine learning concepts in systems biology, integration of large-scale biological datasets.	8
5.	Applications of Systems Biology	Systems medicine and personalized healthcare, disease network analysis, drug discovery and target identification, synthetic biology and metabolic engineering, systems pharmacology, host-microbiome interactions, artificial intelligence in systems biology, precision biotechnology, future directions in systems biology.	8

Learning Resources	
Text Books	***Reference Books***
Systems Biology: A Textbook – Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald.	Network Biology: Methods and Applications. **Editors:** Gerard Cagney, Andrew Emili, **Publisher:** Humana Press (Springer) **Series / Volume:** Methods in Molecular Biology, Vol. 781, 2011, 437 pages
An Introduction to Systems Biology – Uri Alon.	Artificial Intelligence in Precision Health, **Editors:** Debmalya Barh, Sandeep Tiwari, Elsevier 2020
Mathematical Modeling in Systems Biology. Brian P. Ingalls, Publisher: MIT Press	Computational Systems Biology, **Editors:** Andres Kriete and Roland Eils, 2006 (Elsevier Academic Press)

Gaps in the Syllabus (to meet Industry/Profession requirements)	Nil
Pos met through Gaps in the Syllabus	Nil
Topics beyond syllabus/Advanced topics/Design	Nil
Pos met through Topics beyond syllabus/Advanced topics/Design	Nil

Course Outcome (Co) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment	***Assessment Tool***	***% Contribution during CO Assessment***				
	Continuous Internal Assessment	50%				
	Semester End Examination	50%				
	Continuous Internal Assessment	***% Distribution***				
	Best 2 Quiz marks out of 3 Quizzes of 15 marks each.	30%				
	Assignment(s)	10%				
	Seminar before a Committee	10%				
	Assessment Components	***CO1***	***CO2***	***CO3***	***CO4***	***CO5***
	Continuous Internal Assessment					
	Semester End Examination					

Indirect Assessment	

Mapping Between Course Outcomes and Program Outcomes						
CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	**3**	**1**	2	2	2	2
CO2	2	**1**	2	2	2	2
CO3	2	**1**	2	2	2	3
CO4	2	**1**	**3**	2	**3**	3
CO5	1	**1**	**3**	2	3	**3**

Course Delivery Methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL materials and internets
CD7	Simulation

Mapping Between Course Outcomes and Course Delivery Method	
Course Outcomes	**Course Delivery Method**
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD4
CO4	CD1, CD2, CD3, CD4
CO5	CD1, CD2, CD3, CD4, CD5, CD6, CD7

Course Designers		
Experts from Industry	***Experts from Higher Technical Institutions***	***Internal Experts***