गोंय विद्यापीठ
ताळगांव पठार,
गोंय – ४०३ २०६
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GU/Acad –PG/BoS -NEP/2025-26/349 Date: 20.08.2025

CIRCULAR

The Academic Council & Executive Council of the University has approved Ordinance OA-35A relating to PG Programmes offered at the University campus and its affiliated Colleges based on UGC 'Curriculum and Credit Framework for Postgraduate Programmes'. Accordingly, the University has proposed introduction of Ordinance OA-35A from the Academic year 2025-2026 onwards.

The Programme structure and syllabus of Semester I and II of the **Master of Science in Marine Biotechnology** Programme approved by the Standing Committee of the Academic Council in its meeting held on 24th & 25th June 2025 is attached.

The Dean & Vice-Dean (Academic) of the School of Biological Sciences and Biotechnology are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.08.20 17:33:05 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,
1. The Dean, School of Biological Sciences and Biotechnology, Goa University.
2. The Vice-Dean (Academic), School of Biological Sciences and Biotechnology, Goa University.

Copy to:
1. Chairperson, BoS in Biotechnology, Goa University.
2. Programme Director, M.Sc. Marine Biotechnology, Goa University.
3. Controller of Examinations, Goa University.
4. Assistant Registrar Examinations (PG), Goa University.
5. Director, Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENCE IN MARINE BIOTECHNOLOGY

(Effective from the Academic Year 2025-26)

ABOUT THE PROGRAMME

M.Sc. Marine Biotechnology program through its School of Biological Sciences and Biotechnology offers a two-year, full-time postgraduate course designed to provide students with an in-depth understanding of marine biological systems and their biotechnological applications. The program was started in the year 1988 when the DBT (Department of Biotechnology, Ministry of Science & Technology, Govt. of India) identified Goa University as the first institution to run the nationally sponsored HRD programme of M.Sc. in Marine Biotechnology. Candidates qualify for the programme through the national selection process (currently through the GAT-B (Graduate Aptitude Test - Biotechnology) managed by the Regional Centre for Biotechnology (RCB), Faridabad on behalf of the DBT, Govt. of India. Qualifying students receive a studentship of Rs. 5,000/- p.m. during their two-year study period

OBJECTIVES OF THE PROGRAMME

The M.Sc. in Marine Biotechnology program is designed to equip students with cutting-edge knowledge and practical skills in marine biology and biotechnology. It offers in-depth training in molecular biology, omics, aquaculture, and marine bioresources, with a strong emphasis on sustainable resource utilization and conservation. Through research projects, field-based learning, and hands-on laboratory work, students gain valuable experience that prepares them for diverse career paths. Students of this program are well-positioned for opportunities in marine biotechnology industries, environmental and fisheries research institutes, academia, and doctoral studies in India and abroad. The program also fosters interdisciplinary learning, scientific communication, and ethical research practices—empowering students to innovate and lead in the growing field of marine biotechnology.

Approved by: Standing Committee of the Academic Council on 24th & 25th June 2025

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	Core Disciplinary Knowledge in marine molecular and cellular biology: Demonstrate understanding of molecular, genetic, and cellular mechanisms in marine organisms; apply lab techniques such as tissue culture and recombinant DNA tools; analyze cellular processes using advanced instrumentation.
PSO 2.	Application of Marine Analytical and Oceanographic Tools: Utilize oceanographic and analytical techniques to study marine systems; apply tools like spectrometry, chromatography, and imaging in biodiversity and pollution assessment in coastal ecosystems.
PSO 3.	Developing Computational Skills in Marine Biology: Apply bioinformatics and statistical methods to analyze marine biological datasets; interpret genomic and proteomic data; develop predictive models for ecosystem dynamics and marine drug discovery.
PSO 4.	Creating and Evaluating Bioprocesses for Sustainable Marine Bio-products and Technologies:- Design and optimize bioprocesses for marine-derived products, including nutraceuticals, aquaculture outputs, and bioremediation tools, with emphasis on sustainability and local industry relevance.
PSO 5.	Applying Biosafety and Nanotechnology Principles in Marine Biotech Research and Innovation:- Follow biosafety protocols in handling marine biomaterials and nanomaterials; synthesize and characterize marine nanopharmaceuticals; understand IPR and patent norms in the Indian and global context.
PSO 6.	Evaluating Ethical, Legal, and Policy Frameworks in Marine Biotechnology for Sustainable and Inclusive Decision-Making: Evaluate ethical, legal, and policy aspects of marine biotechnology; understand frameworks governing biodiversity conservation and support community-inclusive sustainable development.
PSO 7.	Designing and Translating Marine Biotech Research into Sustainable Innovations for the Blue Economy: Design and execute original research in marine biotechnology; practice ethical publishing; translate innovations into entrepreneurial ventures aligned with Goa's blue economy initiatives.
PSO 8.	Applying and analyzing Molecular and Synthetic Biology to Develop Practical Solutions in Marine Biotechnology: Integrate cell, molecular, and synthetic biology techniques to solve real-world marine challenges; develop industry-relevant solutions and products with vocational impact.

PROGRAMME STRUCTURE

M.Sc. Marine Biotechnology

Effective from Academic Year 2025-26

BRIDGE COURSE*			
Sr. No.	**Course Code**	**Title of the Course**	**Credits**
1	GBT-1000	Concepts in Microbiology	2
2	GBT-1001	Basics in Biochemistry	2
3	GBT-1002	Basics of Cell Biology and Genetics	2

*Students will be provided with the option to do any of the above bridge courses

SEMESTER I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	MBT-5000	Advanced Genetics and Molecular Biology	3	400
2	MBT-5001	Immunology and marine pathogenesis	3	400
3	MBT-5002	Bioanalytical Techniques and Applications	3	400
4	MBT-5003	Oceanography and Marine Bioresources	3	400
5	MBT-5004	Lab I: Molecular Biology, Immunodiagnostics & Marine Pathogenesis	2	400
6	MBT-5005	Lab II: Bio-analytical Tools and Oceanographic Techniques	2	400
Total Credits for DSC Courses in Semester I			**16**	
Discipline Specific Elective (DSE) Course (4 credits) *				
Sr. No.	**Course Code**	**Title of the Course** (Anyone option with 3 credit theory and respective one credit practical)	**Credits**	**Level**
1	MBT-5201	Computational Biology and Data Analysis	3	400
2	MBT-5202	Lab III: Computational Biology & Data Analysis	1	400
3	MBT-5203	Environmental Biotechnology and Sustainability	3	400
4	MBT-5204	Lab IV: Environmental Biotechnology	1	400
5	MBT-5205	Cell and Developmental Biology	3	400
6.	MBT-5206	Lab V: Cell Biology	1	400
Total Credits for DSE Courses in Semester I			**4**	
Total Credits in Semester I			**20**	

*For all practical (laboratory) courses, enrolment in the corresponding theory paper is mandatory in the same semester.

SEMESTER II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	MBT-5006	Biomanufacturing and bioprocess Technology	3	500
2	MBT-5007	Recombinant DNA Technology	3	500
3	MBT-5008	Cell and Tissue Culture: Techniques and Applications	3	500
4	MBT-5009	Plant and Animal Biotechnology	3	500
5	MBT-5010	Lab VI: Recombinant DNA Technology and Bioprocess Technology	2	500
6	MBT-5011	Lab VII: Cell and Tissue Culture	2	500
Total Credits for DSC Courses in Semester II			**16**	
Discipline Specific Elective (DSE) Courses (4 credits) *				
Sr. No.	**Course Code**	**Title of the Course** (Anyone option with 3 credit theory and respective one credit practical)	**Credits**	**Level**
1	MBT-5207	IPR, Biosafety and Bioethics	3	400
2	MBT-5208	Lab VIII: IPR database, Patent drafting, and Bioethics	1	400
3	MBT-5209	Systems Biology	3	400
4	MBT-5210	Lab IX: Practical Approaches to Systems Biology	1	400
Total Credits for DSE Courses in Semester II			**4**	
Total Credits in Semester II			**20**	

*For all practical (laboratory) courses, enrolment in the corresponding theory paper is mandatory in the same semester.

BRIDGE COURSES

Title of the Course	Concepts in Microbiology
Course Code	GBT-1000
Number of Credits	2
Theory/Practical	Theory
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	To understand: ● Key historical developments, terminologies, and the structure and function of microbial cells ● Microbial growth and nutrition ● The role of microorganisms in health, industry, and the environment, including extremophiles and pathogens.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Visualize the contribution of different scientist for the development of microbiology	PSO1
	CO 2. Describe the morphology, structure and organization of microbes	PSO1, PSO2
	CO 3. Explain the microbial growth phases, kinetics and nutrition	PSO1, PSO2, PSO3

	CO 4. Summarize the diversity of microorganisms in different environments and their application		PSO2, PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	a) **A brief history of microbiology**: Discovery of the microbial world, controversy over spontaneous generation, the role of microorganisms in the causation of disease, development of various microbiological techniques, establishment of various branches of microbiology with special reference to the pioneering work by various scientists. b) **An overview of the organization and cell structure of Prokaryotes and Archaea**: **Cell organization**: Cell size, shape, and arrangement, glycocalyx, capsule, flagella, fimbriae, and pili. **Cell-wall**: Composition and detailed structure of gram-positive and gram-negative cell walls, Archaebacterial cell wall, Gram and acid-fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall. **Cell Membrane**: Structure, function, and chemical composition of bacterial and archaeal cell membranes. **Cytoplasm**: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome, and plasmids; Endospores c) **Modern /contemporary microbiology in the 21st century**: - An overview of the Scope of Microbiology	**15**	CO1, CO2	K1, K2
Module 2:	**Growth and nutrition** Microbial nutrition: i) autotrophic & heterotrophic modes, ii) **Culture media**: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media. **Bacterial growth kinetics**: i) growth curve, the mathematical expression of growth & measurement of growth ii) synchronous growth iii) factors affecting growth.	**15**	CO3, CO4	K1, K2

	Microbial taxonomy: i) nomenclature ii) polyphasic identification, traditional & molecular, iii) Bergey's manual. **General characteristics and functions of**: -Algae, Fungi, Cyanobacteria, Bacteria, Viruses, Viroids & prions.; Specialized microorganisms: - Extremophiles, Anaerobes.			
Pedagogy:	Lectures, tutorials, assignments			
Texts:	1. Atlas, R. M. (1997). *Principles of Microbiology* (latest edition). Wm. C. Brown Publishers. 2. Black, J. G. (2008). *Microbiology: Principles and Explorations* (7th ed.). Prentice Hall. 3. Madigan, M. T., Aiyer, J., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2024). *Brock Biology of Microorganisms* (16th ed.). Pearson. 4. Pelczar Jr., M. J., Chan, E. C. S., & Krieg, N. R. (2023). *Microbiology* (5th ed.). Tata McGraw-Hill. 5. Srivastava, S., & Srivastava, P. S. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht 6. Stanier, R. Y., Ingraham, J. L., Wheelis, M. L., & Painter, P. R. (2005). *General Microbiology* (5th ed.). Macmillan. 7. Tortora, G. J., Funke, B. R., Case, C. L., Weber, D., & Bair, W. (2024). *Microbiology: An Introduction* (14th ed.). Pearson Education. 8. Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2016). *Prescott's Microbiology* (10th ed.). McGraw-Hill Education. 9. Reed, G. (1987). *Prescott & Dunn's Industrial Microbiology*. CBS Publishers.			
References/ Readings:	1. https://pmc.ncbi.nlm.nih.gov/articles/PMC7123386/. 2. www.researchgate.net/figure/A-comparison-of-a-few-traits-of-bacteria-archaea-and-eukarya_tbl1_313744700 3. https://pmc.ncbi.nlm.nih.gov › articles › PMC7173489			

Title of the Course	Fundamentals in Biochemistry
Course Code	GBT-1001
Number of Credits	2
Theory/Practical	Theory
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	● The course is designed to impart understanding of basic biochemical foundations that underpin all living organisms, ● To understand concepts about pH, buffering, bioenergetics, nucleotides, amino acids, carbohydrates, lipids, proteins, enzyme function, enzyme kinetics, metabolism, molecular biology and protein chemistry. ● To build upon the knowledge of basic biochemical principles with an emphasis on different metabolic pathways and their integration. ● To understand the structure-function relationships of biomolecules.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand and describe the structure, function, and interrelationships of carbohydrates, lipids, proteins, and nucleic acids.	PSO1
	CO 2. Gain knowledge of enzymes, their mechanisms of action, and their role in catalyzing biochemical reactions. and learn about enzyme inhibitors and their importance in drug development.	PSO1, PSO2

	CO 3. Understand the role of hormones in regulating various physiological processes, including metabolism and reproduction.		PSO1, PSO2, PSO3	
	CO 4. Understand key metabolic pathways, including carbohydrate, lipid, and protein metabolism, and understand how they are regulated.		PSO2, PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	● Biochemistry: the molecular logic of life. ● Amino acids, proteins, nucleic acids, carbohydrates, and lipids. ● Vitamins and hormones. ● Forces that stabilize biomolecules: electrostatic and Vander Waal's interaction, hydrogen bonding. Interactions with solvents, Hydrophobic effect. ● Basic Thermodynamics: Laws of thermodynamics. Concepts of ΔG, ΔH, and ΔS. ● Chemical kinetics: Concepts of Order and molecularity of a chemical reaction. Derivation of first and second-order rate equation, measurement of rate constants. Concept of activation energy. ● Enzymology: Introduction and classification of enzymes. Types of enzymatic reaction mechanisms, Enzyme kinetics, enzyme inhibition, Regulatory enzymes. Isozymes, Zymogen and Ribozyme. Examples of enzymatic reactions.	**15**	CO1, CO2, CO3	K1,K2
Module 2:	● Basic concepts and design of metabolism - glycolysis, gluconeogenesis ● Pyruvate oxidation, Citric acid cycle, Oxidative phosphorylation; the importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation, inhibitors of electron transport chain. ● Glyoxylate cycle ● The pentose phosphate pathway ● Fatty acid synthesis, β-oxidation; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and the mevalonate pathway	**15**	CO3,CO4	K1, K2

	• Amino acid metabolism; nucleotide metabolism • Photosynthesis and photorespiration			
Pedagogy:	Lectures, tutorials, assignments			
Texts:	1. R. L . Miesfeld, M. M. McEvoy, Biochemistry. Worldwide publisher, 2020. 2. D.L. Nelson, Lehninger Principles of Biochemistry. W.H. Freeman & Co., 2017. 3. D. Papachristodoulou, A. Snape, W. H. Elliott, and D. C. Elliott, Biochemistry and Molecular Biology. Oxford University publisher, 2018. 4. L. Stryer, J. Berg, J. Tymoczko, G.Gatto. Biochemistry New York, Freeman publisher.,2019. 5. D. Voet, J.G. Voet, W.P.Charlotte, Principles of Biochemistry. Wiley publisher, 2012. 6. D. Voet, J.G. Voet, W.P.Charlotte, Fundamentals of Biochemistry. Life at the molecular level. Wiley publisher, 2018.			
References/ Readings:	1. E. E. Abali, S. D. Cline, D. S. Franklin, S. M. Viselli, Lippincott Illustrated Reviews: Biochemistry Wolters Kluwer publisher, 2021. 2. R. . Murray, et al. Harper's llustrated Biochemistry McGraw Hill publisher, 2022.			
Web Resources:	1. https://bio.libretexts.org/Bookshelves/Biochemistry/Fundamentals_of_Biochemistry_(Jakubowski_and_Flatt) 2. https://archive.org/details/FundamentalsBiochemistry4e_201802 3. https://labalbaha.wordpress.com/wp-content/uploads/2014/04/fundamentals-of-biochemistry.pdf			

Title of the Course	Basics of Cell Biology and Genetics
Course Code	GBT-1002
Number of Credits	2
Theory/Practical	Theory
Effective from AY	2025-2026
New Course	No
Bridge Course/ Value added Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide a foundational understanding of cell biology by exploring the structure, function, and interactions of cellular components essential for comprehending advanced biological systems. • To introduce the structure and function of prokaryotic and eukaryotic cells, including organelles and membranes. • To highlight the roles of biomolecules such as DNA, RNA, and proteins in cellular processes and understand the molecular basis of gene expression, including transcription, translation, and regulation. • To provide information of the key cellular processes such as the cell cycle, cell signalling, and transport mechanisms.	
Course Outcomes:	At the end of the course, the students will be able to:	**Mapped to PSO**
	CO 1. Explain basic fundamental concepts and principles of cell biology, cell theory and cell evolution.	PSO1, PSO2
	CO 2. Describe the structure and function of major cellular components to develop a foundational understanding of advanced cellular processes.	PSO1, PSO2, PSO3

	CO 3. Explain genetic principles, DNA structure, and chromosome organization		PSO1, PSO2	
	CO 4. Apply – Utilize RNA and ribosome functions in gene regulation and expression		PSO1, PSO2	
	CO 5. Evaluate chromosomal aberrations, polyploidy, repetitive DNA's role in genome stability and mutation		PSO1, PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Biochemical organisation of the cell; diversity of cell size and shape; cell theory, and the emergence of modern Cell Biology. Principles underlying microscopic techniques for the study of cells. Structure and diversity of biological membranes; mechanisms of membrane transport. Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane assembly. Basic cell organelles, structure and function: Cytoskeleton, nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, lysosomes, Chloroplast, peroxisomes, vacuoles. Cell motility.	**15**	CO1, CO2	K1, K2
Module 2:	Mendelian Genetics and Population genetics, Discovery of DNA structure, Structure of DNA - A,B, Z and triplex DNA, Chromosome structure, Telomere, Centromere, Types of RNA, Structure of RNA, Ribosomes, Types of DNA repetitive sequences in DNA, Heterochromatin, Euchromatin, Plasmid as extrachromosomal DNA, DNA polyploidy, Chromosomal aberration and genetic diseases	**15**	CO3, CO4, CO5	K1, K2
Pedagogy:	Lectures, tutorials, assignments			
References/ Readings:	1. Amon, M. Krieger, H. Lodish, , A. Bretscher , C. A. Kaiser, A.Berk , K. C. Martin, H. Ploegh, Molecular Cell Biology. United Kingdom: W. H. Freeman, 2016. 2. C. Smith, Wood Cell Biology, Chapman Hall, 2005. 3. G. M. Cooper and R. E. Hausman, The Cell: A Molecular Approach. United States: Sinauer Associates, 2013.			

SEMESTER I

Discipline Specific Core Courses

Title of the Course	Advanced Genetics and Molecular Biology
Course Code	MBT-5000
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL
Course Objectives:	This course explores molecular mechanisms governing genetic information, focusing on DNA mutation, repair, and transfer in prokaryotic and eukaryotic systems. It covers chromosome organization, gene regulation, transcriptional and translational control, and the central dogma of molecular biology. Students will examine epigenetic regulation, genetic variation, and gene editing technologies, including CRISPR and non-coding RNA applications. Emphasis is placed on DNA replication, cell cycle checkpoints, and nucleocytoplasmic trafficking, providing insights into development

Course Outcomes:			**Mapped to PSO**	
	CO 1. Understand fundamental genetic mechanisms like DNA repair, mutation, and horizontal gene transfer in prokaryotes and eukaryotes.		PSO1, PSO8	
	CO 2. Apply molecular biology principles to analyze chromosome organization, gene regulation, and RNA transport.		PSO1, PSO8	
	CO 3. Evaluate epigenetic regulation and its impact on gene expression, development, and human health.		PSO1, PSO8, PSO3	
	CO 4. Analyze gene editing technologies like CRISPR and non-coding RNA for clinical applications.		PSO1, PSO7, PSO8	
	CO 5. Assess DNA replication fidelity and cell cycle checkpoints in genome stability.		PSO1, PSO3, PSO8	
	CO 6. Design experimental approaches for gene regulation and nucleocytoplasmic trafficking		PSO1, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	DNA: Physical and Chemical agents in Mutation and DNA repair in prokaryotes and eukaryotes. Horizontal gene transfers in prokaryotes and eukaryotes, Transposons, Encoding genetic information and decoding the codon, Central Dogma: Flow of Genetic information, polymerases, Transcriptional and Translational Control.	**15**	CO1, CO2	K2, K3
Module 2:	Chromosome organization, DNA Topology, Mitochondria and chloroplast genome, Nuclear envelop and nucleocytoplasmic trafficking, RNA transport, Structure and role of transcription factors, Genetic variation,	**15**		K2, K3
Module 3:	DNA replication and cell cycle checkpoints, Overview of Gene regulation, Mechanisms of Epigenetic regulation, Role of epigenetics in development/ differentiation and human health, Gene editing and silencing: Non-coding RNA and CRISPR in gene regulation and clinical application	**15**		K2, K3, K4
Pedagogy:	Lecture, Tutorial, Assignments			

References/ Readings:	1. D. P. Clark, N. J. Pazdernik and M. R. McGehee, Molecular Biology (3rd) Elsevier Inc, 2019. 2. W. Klug, M. Cummings and C. Spencer, Concepts of Genetics (12ed), Pearson publishers, 2019. 3. E. S. Goldstein , T. Stephen, J. Kilpatrick and J. Krebs, Lewin's gene XII, Bartlett Publishers, 2017. 4. H. F. Lodish, A. Berk, C. Kaiser, M. Krieger and A. Bretscher, Molecular Cell Biology (8 ed) Freeman MacMillan publisher, 2016. 5. P. J. Russell, iGenetics: A Molecular Approach, Pearson publisher, 2016. 6. G. arp, J. wasa and W. Marshall, arp's Cell and Molecular Biology: Concepts and Experiments, (8 ed) Wiley Publisher, 2016. 7. M. Strickberger, Genetics, (3 ed) by Pearson publishers, 2015. 8. M. J. Simmons and P. Snustad, Principles of Genetics (7 ed), Wiley Student Edition, 2015. 9. J. D. Watson, T A Baker, S P Bell, A Gann, M Levine and R Losick, Molecular Biology of the Gene, Cold Spring Harbor Laboratory Press, New York, 2014. 10. R. F. Weaver, Molecular Biology (5th ed) McGraw Hill HigheR Education publisher, 2012.
Web Resources:	1. https://dnalc.cshl.edu/ 2. https://csh.com.sg/

Title of the Course	Immunology and Marine Pathogenesis
Course Code	MBT-5001
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide foundational understanding of immune system components and antigen recognition mechanisms. • To equip students with the ability to analyze and apply immunological principles in understanding immune responses, tolerance, and disease processes relevant to biomedical research.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify key cells, organs, and molecular components of the immune system and describe their roles in innate and adaptive immunity	PSO1, PSO2
	CO 2. Illustrate the structural and functional organization of MHC molecules and explain how antigens are processed and presented to lymphocytes.	
	CO 3. Compare the maturation pathways and activation mechanisms of B and T lymphocytes.	
	CO 4. Demonstrate the mechanism of antigen-antibody interactions and evaluate the function of	

	immunoglobulins in humoral immune responses			
	CO 5. Analyze the causes and impacts of major diseases and microbial hazards affecting marine fish and shellfish health, including host-pathogen interactions and environmental stressors			
	CO 6. Evaluate and apply immunological strategies, including the use of probiotics, vaccines, and biosecurity measures, for effective disease prevention and health management in aquaculture.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Immunology** • History of immunology • Innate immunity: components, features, and processes • Acquired immunity: specificity, memory, recognition of self vs. non-self • Complement system: Nature, components of the complement. **Immune System Architecture** • Hematopoiesis and differentiation • Myeloid and lymphoid lineages • Cells of the immune system: B cells, T cells, macrophages, dendritic cells, NK cells, mast cells, eosinophils • CD markers and lymphocyte subpopulations • Organization of lymphoid organs: Thymus, Bone marrow, Spleen, Lymph nodes, MALT, GALT, SALT **Antigen Recognition and Presentation** • Nature of antigens, haptens, epitopes, carriers, superantigens, and adjuvants • Major Histocompatibility Complex (MHC): o Discovery, structure (Class I and II), and peptide-binding o Role in immune response and restriction • Antigen processing and presentation to CD4+ and CD8+ T cells	**15**	CO1, CO2	K1, K2

	• Antigen receptors (BCR, TCR) and accessory molecules of T cells			
Module 2:	**Humoral Immunity** • Immunoglobulins: structure, types, distribution, and functions • Antibody production: primary vs. secondary responses • Antibody diversity: Somatic recombination, V (D) J recombination, Combinatorial diversity, Junctional diversity. **Cell-Mediated Immunity** • T cell subsets (Th1, Th2, Th17, Treg) and their roles • Antibody-dependent cell-mediated cytotoxicity (ADCC) **Lymphocyte Maturation and Activation** • General features of lymphocyte maturation • B and T cell maturation pathways • T cell activation: o Signal transduction pathways (Ras/Rac, Calcineurin, PKC) o Activation of transcription factors (NFAT, AP-1, NF-κB) • B cell activation: o BCR signaling and coreceptors o Role of CD40 and T-B cooperation o Bidirectional molecular interactions	**15**	CO3, CO4	K2, K3
Module 3:	**Marine Pathogenesis** **Marine Fish and Shellfish Health** • Introduction to finfish and shellfish diseases: bacterial, fungal, parasitic, nutritional, and environmental etiologies. • Environmental stress and immunocompetence in marine species **Microbial Hazards in Aquatic Systems**	**15**	CO5, CO6	K2, K4, K5

	• Human bacterial pathogens associated with fish and fishery products: *Aeromonas* spp., *Clostridium* spp., *Listeria* spp., *Plesiomonas*, *Salmonella* spp., *Staphylococcus aureus*, *Vibrio* spp., and Enterobacteriaceae. • Biofilm-associated infections in marine systems • Marine biotoxins as biological hazards associated with fish and fishery products **Host-Pathogen Interactions and Immune Defense** • Immunological responses of fishes and shellfishes to infections • Immunostimulants, probiotics, and vaccines in aquaculture **Disease Prevention and Control Strategies** • Prevention and control of fish diseases in aquaculture.1			
Pedagogy:	Lectures/Tutorials/Assignments/Seminar			
Texts:	1. Brostoff, J., Male, D. K., & Roitt, I. M. (2001). *Immunology*. Mosby. ISBN 9780723431893 2. Burton, D. R., Delves, P. J., Martin, S. J., & Roitt, I. M. (2011). *Roitt's essential immunology* (Includes desktop edition). Wiley. ISBN 9781405196833 3. Goldsby, R. A., Kindt, T. J., Osborne, B. A., & Kuby, J. (2007). *Kuby immunology* (6th ed.). W. H. Freeman. ISBN 9780716767640 4. Kimball, J. W. (1990). *Introduction to immunology*. Macmillan. ISBN 9780023646119 5. Luttmann, M., Bratke, K., Kupper, M., & Myrtek, D. (2006). *Immunology*. Academic Press. ISBN 9780120885442 6. Murphy, K., & Weaver, C. (2017). *Janeway's immunobiology* (9th ed.). Garland Science/Taylor & Francis Group. ISBN 9780815345053 7. Murray, P. R., Rosenthal, K. S., & Pfaller, M. A. (2016). *Medical microbiology* (8th ed.). Elsevier. ISBN 9780323299565 8. Weir, D. M. (Ed.). (1996). *Weir's handbook of experimental immunology* (Vols. 1–4). Wiley. ISBN 9780865427984			
References/ Readings:	1. Amillano-Cisneros, J. M., Fuentes-Valencia, M. A., Leyva-Morales, J. B., Savín-Amador, M., Márquez-Pacheco, H., de Jesús Bastidas-Bastidas, P., ... & Badilla-Medina, C. N. (2025). Effects of microorganisms in fish aquaculture from a sustainable approach: a review. *Microorganisms*, *13*(3), 485. 2. Daguer, H., Hoff, R. B., Molognoni, L., Kleemann, C. R., & Felizardo, L. V. (2018). Outbreaks, toxicology, and analytical methods of marine toxins in seafood. *Current Opinion in Food Science*, *24*, 43-55.			

	3. Leal, J. F., & Cristiano, M. L. (2022). Marine paralytic shellfish toxins: chemical properties, mode of action, newer analogues, and structure–toxicity relationship. *Natural Product Reports*, *39*(1), 33-57. 4. Louzao, M. C., Vilariño, N., Vale, C., Costas, C., Cao, A., Raposo-Garcia, S., ... & Botana, L. M. (2022). Current trends and new challenges in marine phycotoxins. *Marine Drugs*, *20*(3), 198. 5. Ma, K., Bao, Q., Wu, Y., Chen, S., Zhao, S., Wu, H., & Fan, J. (2020). Evaluation of microalgae as immunostimulants and recombinant vaccines for disease prevention and control in aquaculture. *Frontiers in Bioengineering and Biotechnology*, *8*, 590431. 6. Paladini, G., Longshaw, M., Gustinelli, A., & Shinn, A. P. (2017). Parasitic Diseases in Aquaculture: Their Biology, Diagnosis and Control. 7. Srivastava, P. K., & Pandey, A. K. (2015). Role of immunostimulants in immune responses of fish and shellfish. *Biochem Cell Arch*, *15*(1), 47-73. 8. Yu, S., Lu, X., & Lu, H. (2025). Marine microbial biofilms on diverse abiotic surfaces. *Frontiers in Marine Science*, *12*, 1482946.

Title of the Course	Bioanalytical Techniques and Applications
Course Code	MBT-5002
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	The course is designed to provide a 1. broad exposure to basic techniques used in modern biological science and biotechnology research. 2. To impart a basic conceptual understanding of the principles of analytical techniques and emphasize the biochemical/bioanalytical utility of the same. 3. To gain the clear understanding of all analytical techniques such that the barrier to implementing the same is abated.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the basic concepts and principles of bio-analytical instruments and oceanographic tool.	PSO1, PSO2
	CO 2. Learn and apply various tools and techniques used for research in biological science.	PSO1, PSO2, PSO5
	CO 3. Understand the application of advanced bio-analytical instruments, samplers and other techniques in research.	PSO1, PSO2, PSO5

	CO 4. Comprehend the advances in instrumentation in biological science areas.		PSO1, PSO2	
	CO 5. Evaluate the use of appropriate tools/techniques in research.		PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Beer-Lambert law, Electromagnetic radiations, UV/Visible spectroscopy • Fluorescence spectroscopy, Application of fluorescence spectroscopy in biochemical methods. • Energy sources used in spectroscopy techniques • Nuclear magnetic resonance (NMR) Spectroscopy. Application of NMR in biomolecule characterization, identification and molecular confirmation. • Centrifuge: Basic concepts of centrifugation. Calculation of g-value from RPM. Types of rotors used in centrifuge machines • Differential centrifugation, Density gradient centrifugation. Rate zonal centrifugation, Isopycnic centrifugation. • X-ray diffraction, Protein crystallography and applications • Flow Cytometry/FACS • Chromatography Techniques: Paper, TLC, Column, Affinity, Ion-Exchange, Size exclusion, Differential, GC, HPLC.	**15**	CO1, CO2, CO4, CO6	K1, K2, K3, K4 K5
Module 2:	• Microscopy and bioimaging applications: Abbey's law of diffraction, Resolution, Magnification, • Common light sources used in microscopy, • Types of photon detector and their working mechanism • Emission, Excitation, Quenching, Quantum Yield and Stock shift. Fluorescence microscopy techniques and their principles • Confocal microscopy • Nanoscopy Imaging and super-resolution imaging techniques and their applications: • STORM imaging and PALM imaging,	**15**	CO1, CO2, CO3. CO4, CO6	K1, K2, K3, K4 K5

	• Scanning electron microscopy, • Transmission electron microscopy applications in biological material analysis			
Module 3:	**Carbon Measurement Methods** • Principles and applications of CHNS Elemental Analyzer for total organic carbon quantification • Measurement of Total Inorganic Carbon (TIC) using Coulometry • Analysis of Dissolved Organic Carbon (DOC) via High-Temperature Catalytic Oxidation **Oceanographic Instrumentation/ devices** • Sediment Traps: Moored arrays and drifting traps for vertical carbon flux monitoring • Autonomous Platforms: Function and deployment of Gliders, Argo Floats, and Profiling Floats • Current Measurement Devices: Acoustic Doppler Current Profiler (ADCP) and Current Meters **Hydrographic and Water Column Profiling Tools** • Conductivity-Temperature-Depth (CTD) Sensors and Sea-Bird CTD Rosette Systems • Use of Expendable Bathythermograph (XBT) for temperature profiling **Acoustic and Optical Survey Technologies** • Application of Echosounders and SONAR for seabed mapping and biomass detection • Role of Underwater Robots and Vehicles (AUVs/ROVs) in oceanographic exploration **Marine Sampling and Collection Techniques** • Operation of Water Sampling Equipment Nansen, Niskin, Go-flow • Use of Grab Samplers and Corers for sediment collection • Deployment and applications of Plankton Nets for biological sampling	**15**	CO1, CO2, CO3. CO4, CO5, CO6	K1, K2, K3, K4 K5

Pedagogy:	Lectures/tutorials/assignments/models/group discussion
Texts: **References/ Readings:**	1. A. Cooper, Biophysical Chemistry. Royal Society of Chemistry, 2011. United Kingdom 2. C.R. Cantor and P.R. Schimmel, Biophysical Chemistry, 2nd Edn., 1982.USA. 3. Fatima Merchant, Kenneth Castleman, Microscope Image Processing, Second edition, Academic press, 2022. USA. 4. Grasshoff, K., Kremling, K., & Ehrhardt, M. (Eds.). (2009). *Methods of seawater analysis* (3rd ed.). Wiley-VCH. Germany. 5. I. Tinoco, K. Sauer, J. Wang, and J. Puglisi, Physical Chemistry: USA. 6. J. Frank, Three-Dimensional Electron Microscopy of Macromolecular Assemblies. Academic Press., 2006. USA 7. K. E. Van-Holde, C. Johnson, Principles of Physical Biochemistry, 3rd Edn. Prentice Hall, 2010. USA. 8. K. Salman, and Z. Diaz, Principal and Techniques of Bioinstrumentation. Intelliz Publisher, 2016. India. 9. Kennish, M. J. (2000). *Practical handbook of marine science* (3rd ed.). CRC Press. USA 10. M.A. Subramaniam, Biophysics: Principle & techniques. MJP Publishers, 2021. India 11. Medwin, H., & Clay, C. S. (1998). *Fundamentals of acoustical oceanography*. Academic Press. USA. 12. Munn, C. B. (2011). *Marine microbiology: Ecology & applications* (2nd ed.). Taylor & Francis Group. United Kingdom. 13. Principles and Applications in the Biological Sciences. Prentice Hall, Inc. 2013. USA.
Web Resources:	1. Home | Microtutor 2. How to Use a Centrifuge: 14 Steps (with Pictures) - wikiHow 3. IDR: Image Data Resource 4. ImageJ 5. Imaging & Microscopy - Wiley Analytical Science 6. Microscope Image Processing | ScienceDirect 7. Microscopy Imaging Techniques

Title of the Course	Oceanography and Marine Bioresources
Course Code	MBT-5003
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To build a strong foundational understanding of the fundamental principles of oceanography, enabling students to comprehend the structure, dynamics, and complexity of the marine environment. • To familiarize students with the vast biological diversity of marine ecosystems, emphasizing the ecological roles and biotechnological potential of marine microorganisms, flora, and fauna. • To develop a scientific framework for analysing the physical and chemical processes that govern ocean circulation, productivity, and marine ecosystem functioning. • To introduce students to the critical significance of the world's oceans in regulating Earth's climate, biogeochemical fluxes, and weather systems by imparting a deep understanding of oceanic phenomena such as circulation patterns, tides, planetary waves, and major biogeochemical cycles.	
Course Outcomes:	At the end of the course the students will be able to:	**Mapped to PSO**
	CO 1. Describe the structural and functional diversity of marine organisms and explain their	

	adaptations to various marine habitats and ecological niches		PSO2, PSO7	
	CO 2. Analyse the role of microbial interactions and food web dynamics, in regulating marine ecosystem productivity, population structure, and energy flow.			
	CO 3. Apply core principles of ocean circulation—including Coriolis effect, thermohaline circulation, and gyres—to interpret large-scale oceanic and atmospheric phenomena affecting marine environments.			
	CO 4. Interpret the influence of oceanographic phenomena on global climate variability, weather systems, and marine biodiversity distribution.			
	CO 5. Explain the physicochemical properties of seawater and characterize major marine sediment types.			
	CO 6. Critically assess the role of oceanic biogeochemical cycles in maintaining ocean health, productivity, and buffering capacity against anthropogenic stressors like acidification and anoxia.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**<u>Biological Oceanography</u>** **Introduction to the Marine Environment and Life Forms** • Classification of marine environments • Marine biodiversity hotspots and conservation priorities **Marine Microbial Diversity and Interactions** • Marine microbes: viruses, bacteria, archaea, protists, and marine fungi • Microbial interactions: o Microbe–microbe (symbiosis, competition, quorum sensing) o Microbe–seaweed interactions o Microbe–metazoan interactions (holobionts and symbioses) **Planktonic and Primary Producers**	**15**	CO1, CO2	K1, K2, K4, K5

	• Plankton: Phytoplankton & Zooplankton • Marine algae and plants: Seaweeds (macroalgae), seagrasses, and mangrove vegetation **Marine Invertebrates and Vertebrates** • **Invertebrates**: Sponges, cnidarians, polychaetes, crustaceans, molluscs, echinoderms, marine worms, non-craniate chordates • **Vertebrates**: o Marine fishes (bony, cartilaginous, jawless) o Marine tetrapod (amphibians, reptiles, seabirds, marine mammals) **Productivity and Ecosystem Functioning** • Marine biomass production: o Primary production: mechanisms, influencing factors, photosynthetic efficiency. o Secondary production and trophic transfer • Biological Carbon pump and energy flow through marine ecosystems **Biodiversity Assessment and Community Dynamics** • Species richness, abundance, and diversity indices (Shannon, Simpson) • Trophic structure, food web models, and microbial loop dynamics			
Module 2:	**Physical Oceanography** **Ocean–Atmosphere Interface and Energy Exchange** **Ocean Circulation Mechanisms** • Coriolis force and its influence on ocean motion • Ekman transport and Ekman spiral • Langmuir circulation and surface mixing **Ocean Currents and Global Conveyor Belt** • Wind-driven circulation: major surface currents and gyres o Western Boundary Currents (Gulf Stream, Kuroshio, Agulhas, Brazil Current)	**15**	CO3, CO4	K2, K3, K4

	○ Eastern Boundary Currents (Canary, California, Peru, Benguela Current) ○ Equatorial Currents and Countercurrents • Density-driven (thermohaline) circulation and the global conveyor belt • Antarctic Circumpolar Current (ACC) and deep-water formation zones **Large-Scale Oceanic Phenomena and Climate Variability** • Planetary waves: Kelvin and Rossby waves and their significance • Climate oscillations: ○ El Niño–Southern Oscillation (ENSO): El Niño and La Niña events and their global effects ○ Pacific Decadal Oscillation (PDO), North Atlantic Oscillation (NAO), Arctic Oscillation (AO) • Role of oceans in climate regulation and weather systems **Ocean Gyres and Their Role in Marine Ecosystems** • Structure and types: tropical, subtropical, and subpolar gyres • Ecological significance of gyres: productivity zones, garbage patches, nutrient distribution **Waves, Tides, and Extreme Events** • Wind waves, Tides, Tsunamis and internal waves **Ocean Floor Dynamics and Geological Oceanography** • Structure of the ocean basin • Plate tectonics: seafloor spreading, subduction, and oceanic ridges Hydrothermal vents and their role in marine biogeochemistry and extremophile habitats			
Module 3:	**Chemical Oceanography** **Seawater Chemistry and Its Properties** **Characterization of sediments: constituents, texture and mass properties** **Biogeochemical Cycles in the Marine Environment**	**15**	CO5, CO6	K2, K5

	• Carbon cycle: organic/inorganic carbon reservoirs, fluxes, carbonate buffering • Nitrogen cycle: nitrogen fixation, nitrification, denitrification, ammonification • Phosphorus cycle: role in productivity and limiting nutrients • Sulphur cycle: dimethyl sulfide (DMS) and atmospheric connections • Iron cycling: role in ocean productivity and trace metal limitation **Other trace element cycles of ecological significance** **Isotope Geochemistry** • Stable and radioactive isotopes in oceanographic studies • Applications in tracing water masses, productivity, nutrient sources, and paleoclimate reconstruction **Ocean acidification**: causes, chemical reactions, and ecological implications **Oceanic anoxic events and dead zones**: natural and anthropogenic causes, biological consequences.			
Pedagogy:	Lectures/tutorials/Assignments/Seminar/Class discussions			
Texts:	1. Mann, K. H., & Lazier, J. R. N. (2013). *Dynamics of marine ecosystems: Biological-physical interactions in the oceans* (3rd ed.). Wiley-Blackwell. ISBN: 9781118168319.*United States.* 2. Munn, C. B. (2011). *Marine microbiology: Ecology & applications* (2nd ed.). Taylor & Francis Group. *United Kingdom*. 3. Pickard, G. L., & Emery, W. J. (2016). *Descriptive physical oceanography: An introduction* (6th ed.). Elsevier. Netherlands. 4. Stewart, R. H. (2008). *Introduction to physical oceanography*. Texas A&M University. USA. 5. Thurman, H. V., & Trujillo, A. P. (2017). *Essentials of oceanography* (12th ed.). Pearson. United States.			
References/ Readings:	1. Bosch, T. C. (2013). Cnidarian-microbe interactions and the origin of innate immunity in metazoans. *Annual review of microbiology*, *67*(1), 499-518. 2. Doney, S. C., Busch, D. S., Cooley, S. R., & Kroeker, K. J. (2020). The Impacts of Ocean Acidification on Marine Ecosystems and Reliant Human Communities. *Annual Review of Environment and Resources*, *45*, 83-112. 3. Poli, A., Finore, I., Romano, I., Gioiello, A., Lama, L., & Nicolaus, B. (2017). Microbial diversity in extreme marine habitats and their biomolecules. *Microorganisms*, *5*(2), 25.			

	4. Ren, C. G., Liu, Z. Y., Wang, X. L., & Qin, S. (2022). The seaweed holobiont: from microecology to biotechnological applications. *Microbial Biotechnology*, *15*(3), 738. 5. Wang, B., Hua, L., Mei, H., Wu, X., Kang, Y., & Zhao, N. (2024). Impact of climate change on the dynamic processes of marine environment and feedback mechanisms: An overview. *Archives of Computational Methods in Engineering*, *31*(6), 3377-3408. 6. Wang, Q., Hao, F., Xu, C., & Zou, H. (2020). Paleolimnological environments and the formation of high quality source rocks in the Bohai Bay Basin: An integrated geochemical study of biomarkers, stable carbon and oxygen isotopes, and trace elements. *Journal of Petroleum Science and Engineering*, *195*, 107753. 7. Weiland-Bräuer, N. (2021). Friends or foes—microbial interactions in nature. *Biology*, *10*(6), 496.
Web Resources:	1. https://oceanexplorer.noaa.gov/ 2. https://earthdata.nasa.gov/learn

Title of the Course	Lab I: Molecular Biology, Immunodiagnostics & marine pathogenesis
Course Code	MBT-5004
Number of Credits	2
Theory/ Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To impart hands-on training in immunodiagnostic techniques for qualitative and quantitative analysis of antigens and antibodies. • To develop analytical and observational skills for identifying aquatic pathogens and characterizing microbial contaminants.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand and Apply immunodiffusion, ELISA, and agglutination assays to detect and quantify antigens and antibodies	PSO1, PSO2
	CO 2. Analyze antigenic similarities and concentration gradients using radial and double immunodiffusion assays.	

	CO 3. Evaluate pathogen identification approaches and fungal characterization techniques in aquatic organisms and Demonstrate the ability to interpret immunological test results and microscopic observations of blood and hemolymph samples			
	CO 4. Conduct genomic/metagenomic DNA isolation and RNA extraction using molecular techniques.			
	CO 5. Evaluate gene transfer methods (conjugation, transformation) and mutagenesis for genetic modifications			
	CO 6. Design and implement mutation screening protocols (UV/chemical mutagenesis, replica plating) for auxotroph identification.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Molecular Biology** 1.1 Genomic DNA isolation 1.2 UV/Chemical mutagenesis isolation of amino acid auxotroph by replica plating. 1.3 Gene transfer by conjugation 1.4 Gene transfer by transformation 1.5 Metagenomic DNA isolation 1.6 RNA isolation	**30**	CO4, CO5, CO5	K4, K5, K6
Module 2	**Immunology and Marine Pathogenesis** 2.1 Determination of Antibody titre using Double Immunodiffusion assay. 2.2 Assessment of Similarity between antigens using Ouchterlony's Double Diffusion Test. 2.3 Estimation of Antigen Concentration using Radial Immunodiffusion. 2.4 Quantitative Precipitation Assay 2.5 DOT ELISA	**30**	CO1, CO2, CO3,	K2,K3,K4, K5

	2.6 Latex Agglutination 2.7 Immunoelectrophoresis 2.8 Rocket Immunoelectrophoresis 2.9 Observation of cellular components of fish blood and shrimp hemolymph. 2.10 Isolation and characterization of fungi from fish & slide culture of fungi. 2.11 Isolation and characterization of bacterial fish pathogens.			
Pedagogy:	Lectures/ tutorials-assignments/hands-on practical			
References/ Readings:	1. Bullock, G. L. (2014). *Diseases of fisheries*. Narendra Publishing House: New Delhi, India. 2. Edward, J. J. (2010). *Fish disease: Diagnosis and treatment*. Wiley-Blackwell: Ames, IA, USA. 3. Inglis, V. (2013). *Bacterial diseases of fish*. Wiley Publications: Chichester, UK. 4. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. (2001). *Immunobiology: The immune system in health and disease* (5th ed.). Garland Publishing: New York, NY, USA. 5. Joshi, K. R., & Osama, N. O. (2012). *Immunology* (5th ed.). Agrobios Ltd: Jodhpur, India. 6. Talwar, G. P., & Gupta, S. K. (2017). *A handbook of practical and clinical immunology* (Vol. 1). CBS Publishers: New Delhi, India. 7. Thanwal, R. (2014). *A handbook of diseases*. Astha Publishers & Distributors: Jaipur, India.			

Title of the Course	Lab II: Bioanalytical Tools and Oceanographic Techniques
Course Code	MBT-5005
Number of Credits	2
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	The objective of this laboratory course is to • equip students with hands-on skills and conceptual understanding necessary for sampling, analyzing, and interpreting key physico-chemical and biological parameters in marine environments. • Teach the utility of experimental methods/analytical techniques in a problem-oriented manner.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate the utility of analytical techniques in a problem-oriented manner.	PSO1, PSO2, PSO5
	CO 2. Hands-on-training of instrumentation techniques for biological science applications	
	CO 3. Develop proficiency in estimation techniques for key physico-chemical parameters in marine environments using standard oceanographic methods	

	CO 4. Perform water and sediment sampling and explain the principles and relevance behind these collection methods. CO 5. Identify, enumerate, and culture marine plankton; calculate & interpret biodiversity indices to assess community diversity and gain insights into ecosystem health.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• UV-Visible spectroscopy instrument demonstration and experimentation • Biochemical assays using ELISA plate reader. • Fluorescence spectroscopy assay • Compound microscope demonstration and environmental sample analysis under bright-field • Analysis of a biological specimen by SEM • Demonstration of fluorescence microscopy • Fluorescence imaging of fixed stained and live cells • Density gradient ultracentrifugation	**30**	CO1, CO2	K3, K4, K5
Module 2:	• Field-based collection of water samples using Niskin bottles and sediment samples using a grab sampler. • Isolation and culturing of marine bacteria from water and sediment samples using selective and differential media; basic characterization and colony morphology. • Plankton Studies: Phytoplankton and zooplankton sampling and Identification • Assessment of Biodiversity Using Ecological Indices • Observation and Identification of Key Marine Species: Fishes, Invertebrates and vertebrates. • Estimation of Chlorophyll *a* in Water Samples • Quantitative Analysis of Inorganic Nutrients: Nitrites, nitrates, phosphates and silicate.	**30**	CO3, CO4, CO5	K2, K3, K4, K5, K6

	• Estimation of Dissolved Oxygen (DO) • Estimation of Salinity, pH, Alkalinity.			
Pedagogy:	Hands-on experiments in the laboratory, Demonstrations, videos, tutorials			
References/ Readings:	1. B. S. Prakash, Bisen, Laboratory Protocols in Applied Life Sciences., Taylor and Francis Publisher, 2014.United Kingdom. 2. G. John Biological Centrifugation CRC Press, 2020. USA. 3. Grasshoff, K., Kremling, K., & Ehrhardt, M. (Eds.). (2009). *Methods of seawater analysis* (3rd ed.). Wiley-VCH. ISBN: 9783527323103. Germany. 4. K. Ulrich, Fluorescence microscopy: From Principle to application, Wiley Int., 2017. Germany. 5. K. Wilson, J. Walker, (Eds)., Principles and techniques of biochemistry and molecular biology. Cambridge university press, 2010. 6. Strickland, J. D. H., & Parsons, T. R. (1972). *A practical handbook of seawater analysis* (2nd ed.). Fisheries Research Board of Canada. 7. Thomas (1997) key, Phytoplankton identification, Academic Press. USA.			

Discipline Specific Elective Courses

Title of the Course	Computational Biology and Data Analysis
Course Code	MBT-5201
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide foundational and advanced knowledge of computational tools and techniques—including biological databases, sequence analysis, structural bioinformatics, and drug design—for understanding molecular biology and biomolecular interactions. • To develop practical skills in omics data analysis, machine learning, and systems biology, enabling students to analyze complex biological datasets, build predictive models, and derive integrative, systems-level insights.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate understanding and application of biological databases, sequence analysis, and phylogenetic methods.	PSO1, PSO3, PSO4

	CO 2. Interpret and analyze protein structures and predict their conformations using bioinformatics tools and modeling techniques.		PSO3, PSO4	
	CO 3. Apply structural bioinformatics and chemoinformatic techniques to design biologically active molecules and understand drug-target interactions.		PSO3, PSO4, PSO5	
	CO 4. Execute NGS and omics data analysis pipelines and interpret transcriptomic, genomic, and functional annotation outputs.		PSO3, PSO4	
	CO 5. Employ data mining and machine learning methods to extract patterns, classify biological datasets, and evaluate model performance.		PSO3, PSO4	
	CO 6. Integrate multi-omics data and visualize biological networks to infer functional and systemic insights in computational biology.		PSO3, PSO4, PSO5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Biological Databases:** Classification of databases—primary, secondary, and specialized (NCBI, ENSEMBL, RefSeq, UniProt, Expression Atlas, HMDB or KEGG, PDB). **Sequence Analysis and Alignment:** Basics of sequence formats, annotation, and description. Principles of sequence alignment—local vs. global (BLAST, Smith-Waterman, Needleman-Wunsch), Pairwise and multiple sequence alignment (Clustal, MUSCLE), Scoring matrices (PAM, BLOSUM), distance matrices, substitution scores, gap penalties, Statistical significance and evolutionary rationale behind sequence alignments, Motif and pattern identification. **Phylogenetics and Molecular Evolution:** Concepts of molecular evolution and tree-building., Methods: UPGMA, Neighbor-Joining, Maximum Parsimony, Maximum Likelihood, Bayesian inference, Tree evaluation and visualization tools, Comparative discussion of algorithms and their applications in molecular systematics. **DNA Barcoding and Molecular Taxonomy:** Principles and workflow of DNA barcoding, Tools and databases, BOLD, NCBI Taxonomy, and CBOL guidelines,	**15**	CO1, CO5	(K1, K2, K3, K4)

	Applications in species identification, biodiversity studies, and taxonomy, Limitations and considerations in marker choice and data analysis.			
Module 2:	**Protein Structure Hierarchy and Classification:** Overview of protein structural organization—primary, secondary, tertiary, and quaternary structures. Introduction to structural classification databases such as CATH (Class, Architecture, Topology, Homologous superfamily), SCOP (Structural Classification of Proteins), FSSP (Families of Structurally Similar Proteins). **Structural Bioinformatics and Molecular Modelling:** Fundamentals of molecular representation using external and internal coordinates. Introduction to molecular mechanics and force fields. Visualization and simulation of protein 3D structures. Analysis of peptide bonds, torsion angles, and the Ramachandran map. Anatomy of protein domains and folds. **Protein Structure Prediction Methods:** Principles of protein folding and sequence–structure relationships. Approaches to structure prediction such as Homology (Comparative) Modeling, Fold Recognition and Threading, Ab initio Modeling, Emerging AI-based approaches (e.g., AlphaFold), Overview of CASP (Critical Assessment of Structure Prediction) benchmarks. **Computational Design Applications:** In silico design of proteins, enzymes, and synthetic promoters. **Chemoinformatics and Drug Discovery:** Introduction to chemical structure databases (e.g., NCI, PubChem). Fundamentals of receptor-ligand interactions. Structure-Based Drug Design (Binding site identification, docking, and virtual screening), Ligand-Based Drug Design (SAR, QSAR modeling, and pharmacophore development).	**15**	CO2, CO3	(K2, K3, K4, K5, K6)
Module 3:	**Next-Generation Sequencing (NGS) Data Handling:** Overview of sequencing platforms; file formats including FASTQ, BAM, SAM, and VCF; data preprocessing and quality control. **Genome Assembly and Annotation Pipelines:** Sequencing technologies; short-read vs. long-read platforms, Concepts: read trimming, genome complexity, contigs,	**15**	CO4, CO5, CO6	(K3, K4, K5, K6)

	scaffolds, N50, and coverage, Overview of genome annotation methods (gene prediction, functional annotation). **Transcriptome Data Analysis:** Quality assessment using FastQC, read alignment using HISAT2 or STAR, transcript quantification, and differential gene expression analysis. **Functional Enrichment and Pathway Analysis:** Gene Ontology annotation; KEGG and Reactome-based biological pathway analysis for interpretation of gene expression changes. **Omics Data Integration:** Brief overview of analytical workflows in metagenomics, proteomics, and metabolomics for comprehensive biological insights. **Network Biology:** Introduction to gene and protein interaction networks; network visualization and basic analysis for understanding system-level organization. **Exploratory Data Analysis:** Techniques such as boxplots, principal component analysis, and correlation matrices for pattern discovery and data quality assessment. **Machine Learning:** Supervised, semi-supervised, and unsupervised learning approaches, Clustering methods and dimensionality reduction techniques for high-dimensional biological data.			
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: **References/ Readings:**	1. Brown, T.A. (2023). Genomes 5. Garland Science. United States 2. Deonier, R., Tavaré, S., & Waterman, M. (2005). *Computational Genome Analysis: An Introduction.* Springer. Springer Nature Singapore 3. **Gasteiger, J., Engel, T.** (2003). *Chemoinformatics: A Textbook*. Wiley-VCH. Germany 4. **Gu, J., Bourne, P.E.** (2009). *Structural Bioinformatics*, 2nd ed. Wiley. United States 5. Leach, A. R. (2001). *Molecular Modelling: Principles and Applications* (2nd ed.). Pearson. London 6. **Lesk, A.M.** (2019). *Introduction to Bioinformatics*, 5th ed. Oxford University Press, UK. 7. Misra, G., Arivaradarajan, P. (2019). Omics Approaches, Technologies And Applications. Springer. Springer Nature Singapore 8. Rajapakse, J.C., Zhang Y. G. (2009*). Machine Learning in Bioinformatics.* Wiley. United States			
Web Resources:	1. https://pubchem.ncbi.nlm.nih.gov			

	2. https://usegalaxy.org 3. https://www.coursera.org/specializations/genomic-data-science 4. https://www.ebi.ac.uk/training/online/ 5. https://www.ensembl.org 6. https://www.genome.jp/kegg

Title of the Course	Lab III: Computational Biology & Data Analysis
Course Code	MBT-5202
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To enable hands-on experience with key bioinformatics databases, UNIX/Linux environments, and structure-based drug design for real-world biological problem-solving. • To develop practical proficiency in computational tools for biological data analysis, including sequence alignment, gene prediction, phylogenetics, and protein structure modelling.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Recall and Apply shell commands essential for data handling, database navigation and retrieve information from public databases.	PSO1, PSO2
	CO 2. Involves analytical thinking to compare sequences, build evolutionary trees, and understand gene structure across organisms.	PSO3, PSO4
	CO 3. Requires critical assessment of structural bioinformatics outputs and their biological relevance, particularly in drug discovery contexts.	PSO3, PSO4, PSO6

	CO 4. Demonstrates students' ability to integrate multiple tools and concepts to develop novel workflows or protocols in a lab or research context.		PSO4, PSO5, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Basic UNIX/Linux shell commands essential for handling biological data, navigating file systems, and running command-line bioinformatics tools. 2. Hands-on introduction to databases (NCBI, UniProt, PDB, KEGG, etc.) for navigation and data retrieval. 3. Use of different BLAST algorithms; analysis and interpretation of alignment scores, E-values, and identity matrices. 4. Multiple sequence alignment and phylogenetic analysis of nucleotide and protein sequences using tools like ClustalW, MEGA, or PhyML. Comparison of different tree-building methods. 5. Application of ab initio gene prediction programs such as GeneMark and Genscan for prokaryotic and eukaryotic gene structure identification. 6. Use of tools like Primer3, NEB Cutter, and online resources for PCR primer design and identification of restriction enzyme cleavage sites. 7. Perform assembly and genome annotation 8. Construction, visualization, and annotation of 3D protein structures using molecular viewers such as RasMol or Swiss-PDBViewer. 9. Introduction to structure-based drug design; docking ligands to protein targets using SwissDock and interpretation of docking scores and poses.	**30**	CO1, CO2, CO3, CO4	(K1, K2, K3, K4, K5, K6)
Pedagogy:	Practical/ tutorials/assignments/Hands-on- training			
Texts: **References/ Readings:**	1. Baxevanis, A.D., Francis-Ouellette. B. F. (2009). BIOINFORMATICS: A PRACTICAL GUIDE TO THE ANALYSIS OF GENES AND PROTEINS, 3RD ED. Wiley India Pvt. Limited. 2. Campbell (2008). Discovering Genomics, Proteomics and Bioinformatics 2e. CSHL Press, Pearson Education. London 3. **Lesk, A.M.** (2019). *Introduction to Bioinformatics*, 5th ed. Oxford University Press, UK.			

	4. **Xiong, J. (2006).** *Essential Bioinformatics*. Cambridge University Press.
Web Resources:	1. https://info-ee.surrey.ac.uk/Teaching/Unix/ 2. https://www.genome.jp/kegg 3. https://www.ebi.ac.uk/training/online/ 4. https://www.ncbi.nlm.nih.gov/home/tutorials/ 5. https://www.coursera.org/specializations/bioinformatics 6. https://linuxcommand.org/tlcl.php

Title of the Course	Environmental Biotechnology and Sustainability
Course Code	MBT-5203
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To impart knowledge on Biotechnological applications. • To understand the application of biotechnological techniques to solve the environmental challenges. • To understand the impact of genetic manipulation, genomics, and proteomics in environmental biotechnology. • To study the application of new techniques that drive the refinement and improvement of existing biotechnological methods and tools. • Case studies in the context of real problems, enabling the students to better understand how the theory is applied in practice, evaluate the environmental pollution and decide about treatment methods.	
Course Outcomes:	Students will be able to	**Mapped to PSO**
	CO 1. Understand and relate the biotechnology knowledge to environmental challenges.	PSO4, PSO6

	CO 2. Apply their knowledge to analyse and evaluate environmental pollution, and decide about treatment methods.			
	CO 3. Apply their knowledge for the application of sustainable biotechnological processes and Create solutions for betterment of the environment and sustainable development of the society.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Environmental Biotechnology and Sustainability: Scope and applications, Basics of ecosystem structure and function • Environmental Monitoring: Monitoring environmental pollution-Air, water and soil sampling, Analyses of samples. Physical, chemical, biological and molecular methods for the measurement of pollution. Bioindicators, Robust techniques and innovative new concepts for identifying and screening of toxins and pathogens in the environment (genetic and biochemical kits and reagents, and cellular models), e-DNA and Nucleic acid based techniques for analyses of diversity, structure and dynamics of microbial community in wastewater treatment, • Biomarkers, Toxicity testing using biological materials.	**15**	CO1,	K1, K2, K3
Module 2:	• Sewage Treatment: Sewage treatment methods, Recovery of Nitrogen and Phosphorus, Sludge treatment and disposal. • Solid waste treatment: Waste Management for Sustainable Development, Anaerobic digestion, Vermicomposting. • Biotechnology and Sustainable techniques: Genetically manipulated organisms, Nanotechnology in wastewater treatment units, Application of nanomaterials in environmental remediation, Potential modification of wastewater treatment using by employing nanomaterials, Removal of pollutants using nanofiltration techniques, Nanomembranes in wastewater treatment, Nanomaterial based disinfection.	**15**	CO1, CO2	K1, K2, K3

	• Bioremediation: Bioremediation strategies, Phytoremediation; Bioremediation Techniques, Phytoremediation and constructed wetland, Metal Bioremediation, Biochemical Pathways of degradation, Plastic degradation			
Module 3:	• Sustainability: Marine organisms as a source of chemicals, Microbial polymers, Biodegradable plastic, Biofuels, Bioleaching, Carbon Storage and Capture (sequestration, conversion to useful biopolymers, etc.), Prevention of eutrophication. • Biotechnology of the Marine Environment: Bioprospecting, Marine Pollution and its control. • Sustainable Development and Environment friendly practices • Strategies to address ocean acidification, Combating marine pollution • Case studies: Bioremediation, Carbon Storage and Capture, Bioenergy.	**15**	CO3,	K3, K4 K5, K6
Pedagogy:	Lectures/tutorials/assignments/ online/self-study			
Texts:	1. Chaterjee, A. K. (2000). Introduction to environmental biotechnology. PHI, India, 2. Colin, M. (2011). Marine Microbiology: Ecology and applications. Second edition. Garland science, New York, United States 3. King, R. B., Sheldon, J. K., and Long, G. M. (2019). Practical Environmental 4. Rehm, H. J. and Reed, G. (Eds.). (1999). Biotechnology, a comprehensive treatise. 5. Satyanarayana, T. Johri, B. and Anil, T. (Ed.). (2012). Microorganisms in Environmental Management. Springer Publishers, Berlin Germany. 6. Scragg, A. (2005). Environmental Biotechnology. Pearson Education Limited, Second edition. Oxford University Press. Oxford, England. 7. Willey, J. M., Sherwood, L. M., Woolverton, C. J. (2017). Prescott,s Microbiology. (10th Ed.). Mcgraw-Hill Education, New York, NY.			
References/ Readings:	1. Bioremediation: The Field Guide, Lewis Publishers. CRC Press, Boca Raton, Florida. 2. Meena, S. M. and Naik, M. M. (Ed.). (2019). Advances in Biological Science Research: a practical approach. (1st Ed.). Elsevier.			

Web Resources:	1. https://www.epa.gov/ 2. https://cpcb.nic.in/ 3. https://goaspcb.gov.in/other-publications/ 4. https://gwmc.goa.gov.in/download/-

Title of the Course	Lab IV: Environmental Biotechnology
Course Code	MBT-5204
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	1. To impart students with the hands-on experience in basic experimental analysis and the use of biological agents. 2. To understand emerging treatment processes carried out for the wastewater and organic solid waste analysis	
Course Outcomes:		**Mapped to PSO**
	CO 1. To analyse municipal wastewater	PSO4, PSO6
	CO 2. To analyse solid organic waste	
	CO 3. Analyse and evaluate the process of organic waste treatment.	
	CO 4. To relate the knowledge of Environmental Biotechnology with organic waste analysis.	

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	1. Estimation of Total solids and Volatile solids in algal biomass 2. Biochemical methane potential assay of seaweed biomass 3. Total Phosphorus analysis in wastewater 4. Total Nitrogen analysis in wastewater 5. N and P recovery from wastewaters using marine microalgae. 6. Evaluating Microplastic concentration in seawater 7. Field visit to assess the condition of coastal habitats (e.g., Intertidal region, estuarine and mangroves habitats)	**30**	CO1, CO2, CO3, CO4	2 K3 K4 K5 K6
Pedagogy:	Hands-on experiments in the laboratory, online videos.			
Texts:	1. APHA. "Standard Methods for Examination of Water and Wastewater", American Public Health Association WWA, Washington, D.C., 2005. 2. Angelidaki I , Alves M, Bolzonella D, Borzacconi, L. Campos, J.L., Guwy, A.J., Kalyuzhnyi, S., Jenicek P., and Van Lier, J.B., Defining the Biomethane Potential (BMP) of Solid Organic Wastes and Energy Crops: A Proposed Protocol for Batch Assays. Water Science & Technology, 2009.			
References/ Readings:	Scragg, A. (2005). Environmental Biotechnology. Second edition. Pearson Education Limited, Oxford University Press, Oxford, England.			
Web Resources:	https://www.epa.gov/ https://cpcb.nic.in/ https://goaspcb.gov.in/other-publications/ https://gwmc.goa.gov.in/download/-			

Title of the Course	Cell and Developmental Biology
Course Code	MBT-5205
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	1. To enable students to critically understand the structural and molecular dynamics of cellular and developmental processes, and relate these to human health, disease, and therapeutic strategies. 2. To develop the ability to apply, analyze, and communicate key concepts of cellular and developmental biology across model systems using experimental and visual tools relevant to research and biotechnology.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Critically analyze the structural and functional dynamics of cellular organelles and their roles in maintaining cellular homeostasis and contributing to human diseases.	PSO1, PSO7
	CO 2. Interpret and evaluate molecular mechanisms underlying cell signaling, cytoskeletal dynamics, and intercellular communication, with relevance to therapeutic targeting in biotechnology and biomedical research.	

	CO 3. Describe and explain the basic concepts of development and compare and contrast embryonic development across various model organisms (e.g., Drosophila, Xenopus, C. elegans, zebrafish, and mouse).			
	CO 4. Analyse the role of gene expression and signaling pathways (e.g., Hox genes, Wnt, Hedgehog, Notch) in developmental processes and evaluate experimental techniques (e.g., fate mapping, lineage tracing, gene knockouts) used to study developmental biology.			
	CO 5. To examine the genetic and molecular mechanisms underlying floral induction, photoperiodism, and vernalization.			
	CO 6. Discuss the implications of developmental biology in health and disease, including teratogenesis, stem cell therapy, and congenital disorders and communicate developmental biology concepts effectively using scientific terminology and appropriate diagrams or models.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1. Organelle dynamics and intracellular trafficking: Nucleus, Mitochondria, Ribosome, Endoplasmic reticulum, Golgi apparatus, lysosome, Peroxisome, vacuoles, plastids. 1.2. Organelleopathy • Mitochondrial Dysfunction in Metabolic and Neurodegenerative Disease • Endoplasmic Reticulum Stress and Its Role in Disease • Peroxisomes in Lipid Metabolism and Reactive Oxygen Species Detoxification. • The Role of Exosomes and Extracellular Vesicles in Intercellular Communication and Disease Progression 1.3. Cytoskeletal Architecture and Cell Motility. 1.4. Cellular communication: General principles of cell communication, cell adhesion and roles of different adhesion molecules, tight junctions, communicating junctions, integrins, neurotransmission, and its regulation.	**15**	CO1, CO2	K1, K2, K4

	1.5. Cell signalling and Signal transduction mechanisms. 1.6. Programmed cell Death, Aging and Senescence.			
Module 2:	2.1. Cancer Biology 2.2. Introduction to Developmental Biology: Significance of developmental Biology, Model organisms and plants used in developmental Biology: Xenopus, Drosophila, C. elegans, Sea Urchin, Chick, Mouse, Zebra fish, Arabidopsis Thaliana, Rice; Basic concepts and overview of Developmental Biology in animals and plants. 2.3. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination. 2.4. Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.	**15**	CO3, CO4	K1, K2, K3
Module 3:	3.1. Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum.Floral induction and organ identity: floral integrator genes, ABCDE model. 3.2. Difference between Plant and Animal Developmental Biology 3.3 Developmental Plasticity and environmental modulation : Photomorphogenesis: Circadian rhythms, Phytochromes ; Themosensory flowers and Vernalisation 3.4. Developmental process-oriented disorders and Teratogens: Environmental influence on development, cancer as a developmental disorder, Teratogens: endocrine disrupters, alcohol, Retinoic acid and Congenital abnormalities, genetic disorders in development.	**15**	CO3, CO4, CO5 & CO6	K1, K2, K3, K4, K5, K6

	3.5. Experimental Techniques in Developmental Biology: CRISPR-Cas9 gene editing, Lineage tracing and fate mapping, Transcriptomics in developmental studies			
Pedagogy:	Lectures/tutorial/assignments			
References/ Readings:	1. Amon, A., Krieger, M., Lodish, H., Bretscher, A., Kaiser, C. A., Berk, A., Martin, K. C., & Ploegh, H. (2016). *Molecular cell biology*. W. H. Freeman. United Kingdom. 2. Cooper, G. M., & Hausman, R. E. (2013). *The cell: A molecular approach*. Sinauer Associates. United States. 3. Gilbert, S. F. (2010). *Developmental biology*. Sinauer Associates. United States. 4. Hake, S., & Zambryski, P. (1997). *Plant development*. Cold Spring Harbor Laboratory Press. United States. 5. Karp, G., Iwasa, J., & Marshall, W. (2018). *Cell biology global edition*. Wiley. United States. 6. Kilpatrick, S. T., Krebs, J. E., & Goldstein, E. S. (2017). *Lewin's GENES XII*. Jones & Bartlett Learning. United States. 7. Leyser, O., & Day, S. (2003). *Mechanisms in plant development*. Blackwell Publishing. United Kingdom. 8. Lodish, H., & Arnold, B. (2000). *Molecular cell biology*. W. H. Freeman & Company. United States. 9. Pollard, T. D., Earnshaw, W. C., Lippincott-Schwartz, J., & Johnson, G. (2016). *Cell biology (E-book)*. Elsevier Health Sciences. Netherlands. 10. Slack, J. M. W. (2009). *Essential developmental biology*. Wiley. Germany. 11. Smith, C., & Wood, E. (2005). *Cell biology*. Chapman & Hall. United Kingdom. 12. Subramanian, M. A. (2022). *Developmental biology*. MJP Publisher. India. 13. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2015). *Plant physiology and development*. Sinauer Associates. United States. 14. Turner, B. M. (2008). *Chromatin and gene regulation: Molecular mechanisms in epigenetics*. John Wiley & Sons. United Kingdom. 15. Watson, J. D., Levine, M., Baker, T. A., Gann, A., Bell, S. P., & Watson, R. L. (2014). *Molecular biology of the gene*. Pearson Education. United States. 16. Wolpert, L. (2011). *Developmental biology: A very short introduction*. OUP Oxford. United Kingdom.			

Title of the Course	Lab V: Cell Biology
Course Code	MBT-5206
Number of Credits	1
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	• To develop practical skills in cell biology techniques, including microscopy, cell organelle staining, cell fractionation, and analysis of mitosis, meiosis, and karyotyping for understanding cellular structure and function. • To train students in evaluating cell health and behaviour through viability assays, apoptosis detection, and flow cytometry, and prepare them for applications in biomedical and research settings.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate the use of various imaging techniques to study cell morphology and structure using phase contrast, fluorescence, SEM, and TEM.	PSO1, PSO2
	CO 2. Execute cell organelle-specific staining methods to visualize mitochondria, nucleus, and Golgi bodies and Perform cell fractionation to isolate nuclei, mitochondria, and other organelles	PSO1, PSO8

	CO 3. Assess and interpret cell viability and cytotoxic effects using MTT and Trypan Blue assays.		PSO1, PSO8	
	CO 4. Detect and analyze apoptosis using DNA laddering or Annexin V-FITC/PI staining techniques.		PSO1, PSO8	
	CO 5. Demonstrate karyotyping techniques and analyze chromosomal abnormalities or patterns.		PSO1, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1 Cell Imaging Techniques for cell morphological characterisation: Phase contrast and fluorescent Microscopy, Scanning and Transmission Electron Microscopy 1.2 Cell organelles staining techniques: Mitochondria, Nucleus, Golgi bodies 1.3 Cell fractionation / Isolation of the cell organelles: Nuclei, Mitochondria and other organelles 1.4 Cell Viability Test: MTT or Trypan Blue 1.5 Detection of Apoptosis by DNA laddering or Annexin V staining 1.6 Flow cytometry demonstration 1.7 Karyotyping demonstration	**30**	CO1, CO2, CO3, CO4, CO5	K3, K4, K5, K6
Pedagogy:	Hands-on experiments in the laboratory, video, online data			
References/ Readings:	1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular biology of the cell* (6th ed.). Garland Science. **United States**. 2. Bozzola, J. J., & Russell, L. D. (1999). *Electron microscopy: Principles and techniques for biologists* (2nd ed.). Jones & Bartlett Learning. **United States**. 3. Pendergrass, W., Wolf, N., & Poot, M. (2004). Efficacy of MitoTracker Green and CMXRosamine for mitochondrial staining in live cells. *Cytometry Part A, 61*(2), 162–169. https://doi.org/10.1002/cyto.a.20033 4. Kapuscinski, J. (1995). DAPI: A DNA-specific fluorescent probe. *Biotech Histochemistry, 70*(5), 220–233. https://doi.org/10.3109/10520299509108199			

	5. Cole, N. B., Sciaky, N., Marotta, A., Song, J., & Lippincott-Schwartz, J. (1996). Reversible assembly of GFP-tagged Golgi elements in living cells. *The Journal of Cell Biology*, *134*(4), 757–773. https://doi.org/10.1083/jcb.134.4.757 6. Graham, J. M. (2002). Isolation of mitochondria from tissues and cells by differential centrifugation. *Current Protocols in Cell Biology*, *3*(1), 3.3.1–3.3.15. https://doi.org/10.1002/0471143030.cb0303s00 7. Mosmann, T. (1983). Rapid colorimetric assay for cellular growth and survival: Application to proliferation and cytotoxicity assays. *Journal of Immunological Methods*, *65*(1–2), 55–63. https://doi.org/10.1016/0022-1759(83)90303-4 8. Strober, W. (2001). Trypan blue exclusion test of cell viability. *Current Protocols in Immunology*, Appendix 3B. https://doi.org/10.1002/0471142735.ima03bs21 9. Wyllie, A. H. (1980). Glucocorticoid-induced thymocyte apoptosis is associated with endogenous endonuclease activation. *Nature*, *284*(5756), 555–556. https://doi.org/10.1038/284555a0 10. Koopman, G., Reutelingsperger, C. P. M., Kuijten, G. A. M., Keehnen, R. M. J., Pals, S. T., & van Oers, M. H. J. (1994). Annexin V for flow cytometric detection of phosphatidylserine expression on B cells undergoing apoptosis. *Blood*, *84*(5), 1415–1420. https://doi.org/10.1182/blood.V84.5.1415.bloodjournal8451415 11. Robinson, J. P. (Ed.). (2018). *Current protocols in cytometry*. Wiley. United States. 12. Shapiro, H. M. (2003). *Practical flow cytometry* (4th ed.). Wiley-Liss. United States. 13. Rooney, D. E. (2001). *Human cytogenetics: Constitutional analysis* (Vol. 1, 3rd ed.). Oxford University Press. United Kingdom. 14. Barch, M. J., Knutsen, T., & Spurbeck, J. L. (1997). *The ACT cytogenetics laboratory manual* (3rd ed.). Lippincott-Raven. United States.

SEMESTER II

Discipline Specific Core Courses

Title of the Course	Biomanufacturing and Bioprocess Technology
Course Code	MBT-5006
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	MBT-5001	
Course Objectives:	To enable students to understand the bioprocess principles, bioreactor designs and downstream operations, and design optimized biotechnological processes for industrial and marine research applications.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Describe the principles of bioreactor design and operation, and differentiate between types and modes of fermentation processes (batch, fed-batch, and continuous). Apply knowledge of microbial techniques for the isolation, screening, and preservation of industrially important microorganisms, as well as the formulation of culture media for bioprocesses.	PSO1, PSO2

	CO 2. Monitor and control bioprocess parameters such as aeration, agitation, sterilization, and measurement systems to ensure optimal bioprocess performance.		PSO1, PSO2, PSO3	
	CO 3. Analyze the strategies for strain improvement and demonstrate understanding of microbial production processes for industrially significant products such as alcohol, organic acids, antibiotics, amino acids, biopharmaceuticals, and biomass.		PSO4, PSO5	
	CO 4. Understand and describe downstream processing operations, including separation, purification, and recovery of products using techniques such as chromatography, filtration, and crystallization		PSO4, PSO5, PSO7	
	CO 5. Recognize the significance of marine bioprocessing, including the production of bioactive compounds, enzymes, nutraceuticals, and microalgal biomass, and design considerations for marine bioreactors.		PSO5, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Basic Principles of Biochemical Engineering and Fermentation Processes**: • Bioreactors, bioreactor design, criteria, operation and types of bioreactors. • Concepts of basic modes of fermentation: batch, fed- batch and continuous • Isolation, screening, and preservation of industrially important microbes • Design and formulation of Media for industrial bioprocess • Scale up fermentation processes • Air and media sterilization. • Aeration and agitation in bioprocess. • Measurement and control of bioprocess parameters.	**15**	CO1, CO2	K1, K2, K3, K4, K5
Module 2:	**Industrial production of chemicals:** • Strain improvement for increased yield and other desirable characteristics • alcohol (beer), biopharmaceuticals (vaccines) • organic acids (citric acid)	**15**	CO2, CO3	K2, K3, K4, K5

	• antibiotics (Penicillin/streptomycin) • amino acids (lysine/glutamic acid) • Bioprocess for the production of biomass: yeast and mushrooms			
Module 3:	**Downstream Processing and Marine bioprocessing** • steps involved in Downstream processing; bio-separation, filtration, centrifugation, sedimentation, flocculation, cell disruption, liquid- liquid extraction. • Purification by chromatographic techniques • Drying and crystallization. • Bioprocessing of marine natural products-bioactive compounds, marine enzymes, Nutraceuticals; bioreactor considerations for production of marine-derived bioactive compounds, aquaculture bioprocessing of microalgal biomass, nitrifying bioreactor.	**15**	CO4, CO5	K1, K2, K3, K4, K5, K6
Pedagogy:	Lectures, tutorials, assignments.			
Texts:	1. Bailey, J. E., & Ollis, D. F. (2017). *Biochemical engineering fundamentals* (2nd ed.). McGraw Hill Education: New York, NY, USA. 2. Chen, H. (2013). *Modern solid state fermentation: Theory and practice*. Springer: Berlin, Germany. 3. Doble, M., & Gummadi, S. N. (2010). *Biochemical engineering*. PHI Learning: New Delhi, India. 4. El-Mansi, E. M. T., Bryce, C. F. A., Demain, A. L., & Allman, A. R. (Eds.). (2006). *Fermentation microbiology and biotechnology* (2nd ed.). CRC Press: Boca Raton, FL, USA. 5. Lancini, G., & Lorenzetti, R. (2013). *Biotechnology of antibiotics and other bioactive microbial metabolites*. Springer: New York, NY, USA. 6. Palmer, T., & Bonner, P. (2008). *Enzymes: Biochemistry, biotechnology, clinical chemistry* (2nd ed.). Woodhead Publishing: Cambridge, UK. 7. Peppler, H. J., & Perlman, D. (Eds.). (1979). *Microbial technology: Fermentation technology* (2nd ed.). Academic Press: New York, NY, USA. 8. Shuler, M. L., Kargi, F., & DeLisa, M. (2017). *Bioprocess engineering: Basic concepts* (3rd ed.). Pearson Education: Boston, MA, USA. 9. Smith, J. E. (2009). *Biotechnology* (5th ed.). Cambridge University Press: Cambridge, UK.			

	10. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3rd ed.). Butterworth-Heinemann: Oxford, UK. 11. Todaro, C. M., & Vogel, H. C. (2014). *Fermentation and biochemical engineering handbook* (3rd ed.). William Andrew Publishing: Norwich, NY, USA.
References/ Readings:	1. Doran, P. M. (1995). *Bioprocess engineering principles*. Academic Press: San Diego, CA, USA. 2. Doan, H. V., Prakash, P., Hoseinifar, S. H., Ringø, E., El-Haroun, E., Faggio, C., Olsen, R. E., Tran, H. Q., Stejskal, V., Abdel-Latif, H. M. R., & Dawood, M. A. O. (2023). Marine-derived products as functional feed additives in aquaculture: A review. *Aquaculture Reports*, *31*, 101679. https://doi.org/10.1016/j.aqrep.2023.101679 3. Kim, S.-K., & Mendis, E. (2006). Bioactive compounds from marine processing byproducts – A review. *Food Research International*, *39*(4), 383–393. https://doi.org/10.1016/j.foodres.2005.10.010 4. Rao, D. G. (2005). *Introduction to biochemical engineering*. Tata McGraw-Hill: New Delhi, India.
Web Resources:	1. https://www.openaccessjournals.com/journals/pharmaceutical-bioprocessing-citations-report.html 2. www.wildfermentation.com/John Schollar and BenedikteWatmore, Practical Fermentation-a technicalguide 3. web.mit.edu/professional/short.../fermentation_technology.html

Title of the Course	Recombinant DNA Technology
Course Code	MBT-5007
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-2026
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	MBT-5001	
Course Objectives:	To understand: • Various enzymes and techniques for manipulating DNA. • Various DNA vectors and their use in creating recombinant DNA molecules • Recombinant DNA modification techniques and heterologous gene expression used for creating applications for biological research and biotechnology industries.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the role of DNA modifying enzymes in recombinant DNA technology.	PSO1, PSO8
	CO 2. Utilize linkers, adaptors, and hybridization probes for molecular cloning and hybridization respectively	PSO1, PSO8

	CO 3. Evaluate genomic analysis techniques like DNA fingerprinting and sequencing		PSO1, PSO3	
	CO 4. Assess the efficiency of PCR variants and molecular diagnostic approaches		PSO1, PSO3	
	CO 5. Design experiments using CRISPR and gene therapy applications.		PSO1, PSO7, PSO8	
	CO 6. Implement advanced cloning vectors for recombinant DNA research.		PSO1, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	DNA modifying enzymes used in recombinant DNA technology: Type II restriction enzymes, Klenow fragment, T4/T7 DNA polymerases, Reverse transcriptase, Ligases, Kinases, phosphorylases, Terminal transferases, thermostable polymerases, Nucleases, reverse transcriptase. Use of linkers and adaptors in cloning, Non-radiolabeled probes in hybridization	**15**	CO1, CO2	K1, K2, K3
Module 2:	Southern and Western Blotting, DNA fingerprinting, DNA foot-printing, NGS sequencing, Variants of PCR techniques, real-time PCR, MA13 and Phage Display, cDNA library, PCR and applications, Gene therapy, CRISPR application in health	**15**	CO3, CO4, CO5	K3, K4
Module 3:	Cloning Vectors: - pET Series Vectors,- Gateway Cloning Vectors,- BAC & YAC Vectors,- Lentiviral Vectors, CRISPR-Based Vectors, Golden Gate Cloning Vectors, TALEN vectors, Synthetic Biology Vectors, Vectors for gene silencing	**15**	CO6	K5 K6
Pedagogy:	Lectures, Tutorial,			
Texts: **References/ Readings:**	1. T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, Wiley-Blackwell Publishers, 2016. 2. T. A Brown, Genomes, New York: Garland Science Publisher, 2017. 3. J. W. Dale, M. von Schantz and N. Plant, From Genes to Genomes: Concepts and Applications of DNA Technology, Wiley Blackwell publisher, 2011. 4. H. K. Das, Textbook of Biotechnology, Wiley Publisher, 2017. 5. M. R. Green and J. Sambrook, Molecular Cloning: A Laboratory Manual.CSH Press, 2012. 6. V. Hunter and F. Strickland, Applications of Recombinant DNA Technology. ED-TECH Press, 2018. 7. A. J. Nair, Introduction to Biotechnology and Genetic Engineering. Laxmi Publications Pvt. Ltd, 2008.			

	8. S. Primrose and R. B. Twyman, Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited, 2006. 9. M. K. Sarwar, I. A. Khan and D. Barp, Applied Molecular Biotechnology: The Next Generation of Genetic Engineering CRC Press, 2016. 10. V. Singh and P Dhar, Genome Engineering via CRISPR-Cas9 System, Elsevier Publisher, 2020.

Title of the Course	Cell and tissue culture: Techniques and Applications
Course Code	MBT-5008
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	MBT-5000, MBT-5001, MBT-5002	
Course Objectives:	The aim of the course is • Student will learn about cell culture set-up, laboratory design, own safety during work and environment safety • To learn experimental aspects of cell culture, maintenance and handling of cell lines and cultures • To bring together cellular, biochemical, anatomical, histological, physiological and evolutionary medical views of stem cells • To obtain a coherent picture of stem cell and their use in experimental and clinical context	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the principles, applications, and laboratory practices of cell culture, including aseptic techniques and media preparation.	PSO1, PSO2

	CO 2. Perform key procedures for cell line maintenance, including thawing, subculturing, cryopreservation, and contamination control.		PSO2, PSO3	
	CO 3. Describe and apply advanced cell culture methods such as 3D cultures, co-cultures, and transfection techniques.		PSO1, PSO2, PSO3	
	CO 4. Understand the basics of stem cell biology and their culture methods		PSO1, PSO2	
	CO 5. Application of stem cells in regenerative medicine to treat disease		PSO1, PSO2, PSO3	
	CO 6. Recognize quality control, regulatory guidelines, international status, and emerging technologies in cell culture, stem cell biology and regenerative medicine		PSO1	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Introduction to Cell Culture, History and applications of cell culture. • Equipment required to set-up laboratory and their functions • Laboratory setup: • Small, Mid-size and Large-size laboratory design and setup. • Types of cell cultures: primary cells, continuous cell lines, stem cells, Plant tissue culture • Overview of aseptic techniques and contamination control • Cell culture media: composition, preparation, and storage and use	**15**	CO1, CO2	K1, K2, K3
Module 2:	• Cell line maintenance, handling, Primary and secondary cell culture • Culture, thawing, subculturing, and cryopreservation techniques of various cell lines • Cell counting and viability assays (e.g., trypan blue exclusion, live/dead staining), morphological characterization, scoring, and authentication of cell lines • Detection and management of contamination (bacterial, fungal, mycoplasma) • 3D cultures, organoid culture, co-culture systems, advanced cell culture applications, and organoids.	**15**	CO1, CO2, CO3	K2, K3, K4, K5

	• Transfection techniques and genetic manipulation, Microinjection, Electroporation.			
Module 3:	• Definition, stem cell origins and plasticity, classification. • Source of stem Embryonic and adult stem cells; Stem cell differentiation; • Stem cells maintenances and cryopreservation, • Induced Pluripotent stem cell technology (iPS technology) • Stem cell regulation, Tumor stem cells, • Overview of embryonic and adult stem cells for regenerative medicine. • Stem cell-based therapies, case studies • Ethical considerations, Govt. regulations, international regulations on stem cell study	**15**	CO1, CO2, CO3	K1, K2, K3, K4, K5
Pedagogy:	Lectures/tutorials/assignments			
Texts: **References/ Readings:**	1. Wilson And Walkers Principles And Techniques Of Biochemistry And Molecular Biology 8Ed (Sae) (Pb 2023) 2. A.D. Hoffman, Stem Cell Transplantation Biology Process Therapy, Willy- VCH, 2006. 3. J. Collins, Stem cells: From basic to advanced principles, Hayle Medical,2017. 4. R. Lanza, Essential of Stem Cell Biology, Academic Press, 2006. 5. R. Lanza, Essential stem cell methods, Elsevier, 2009. 6. R. Lanza, Principle of Tissue Engineering, AP publisher, 2011. 7. R. Lanza, Essential of Stem cell Biology, Elsevier publisher, 2013.			
Web Resources:	1. Animal Cell Culture: Types, Cell Lines, Procedure, Uses 2. Animal Cell Culture Guide | ATCC 3. Preparation of a universally usable, animal product free, defined medium for 2D and 3D culturing of normal and cancer cells - PMC 4. The Cell Image Library			

Title of the Course	Plant and Animal Biotechnology
Course Code	MBT-5009
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	MBT-5000	
Course Objectives:	• Understand and apply genetic engineering techniques for trait improvement, stress resistance, and value addition in plants and animals. • To develop the ability to evaluate integrated biotechnological applications, including marine systems, with a focus on sustainability, bioresource utilization, and regulatory considerations.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the principles and techniques of genetic modification in plants and animals.	PSO1, PSO8
	CO 2. Compare different vector systems and gene delivery methods used in plant and animal biotechnology.	PSO1, PSO4
	CO 3. Analyze strategies for enhancing stress tolerance and productivity in transgenic plants.	PSO1, PSO4, PSO8

	CO 4. Evaluate biotechnological approaches for trait improvement and disease modeling in marine animals.		PSO1, PSO4, PSO5, PSO8	
	CO 5. Design biofactory-based systems for producing high-value biomolecules in marine plants and animals.		PSO4, PSO7, PSO8	
	CO 6. Assess ethical, regulatory, and societal implications of transgenic technologies and molecular pharming.		PSO5, PSO6, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Plant Biotechnology** **Principles and tools of plant genetic transformation:** Agrobacterium-mediated, biolistic, electroporation. **Development of transgenic plants:** Selection markers, gene stacking, tissue-specific promoters. **Genetic engineering for biotic and abiotic stress tolerance:** Insect/pest resistance (Bt), virus- and fungus-resistance genes, tolerance to drought, salinity, temperature extremes, and flooding. **Metabolic engineering:** Modification of seed storage proteins, production of vitamins and nutraceuticals (Golden Rice), engineering of secondary metabolites. **Biofactories and synthetic biology:** Production of industrial enzymes, pharmaceuticals, and biofuels using transgenic plants and plant cell cultures.	**15**	CO1, CO2, CO3,	K1, K2, K3, K5
Module 2:	**Animal Biotechnology** **Gene transfer methods:** Microinjection, retroviral vectors, electroporation, liposome-mediated delivery, transposons. **Transgenic animal models:** Mice, poultry, fish; their applications in disease research, functional genomics, and toxicity testing. **Cloning and gene editing:** Somatic Cell Nuclear Transfer, CRISPR/Cas systems in livestock.	**15**	CO1, CO2, CO3, CO4, CO6	K1, K2, K3, K5

	Biopharming and therapeutic protein production in animals: Recombinant proteins in milk, eggs. Gene targeting, positive and negative selection, and knockouts for functional genomics. Xenotransplantation and ethical considerations. Animal biotechnology in agriculture: Milk enhancement, disease resistance, growth traits.			
Module 3:	**Applications of biotechnology in marine system** **Section A:** • Cultivation and genetic enhancement of microalgae and macroalgae for biofuels, carbon capture, nutraceuticals, and pharmaceuticals. • Post-harvest biotechnology for seaweeds: improving shelf-life, drying, and preservation; enhancing polysaccharide stability through biotechnological interventions. • Micropropagation of seagrasses and macroalgae for coastal restoration and aquaculture; somaclonal variation and conservation of endangered marine flora. • Genome editing in marine photosynthetic organisms to improve lipid metabolism, stress tolerance, and pigment production. • Case studies: Engineered microalgae for omega-3 production **Section B:** • Assisted reproduction in aquaculture species: IVF, cryopreservation, sex control, gamete manipulation, and surrogate broodstock development in finfish and shellfish. • Genomic tools for breeding: marker-assisted selection, genomic selection, and omics approaches for trait improvement. • Regulatory frameworks and biosafety considerations in marine genetically modified organisms (GMOs).	**15**	CO4, CO5, CO6	K3, K4, K5, K6

	• Case studies: AquAdvantage salmon (regulatory, ecological, and ethical dimensions); GM mollusks for biotoxin detection.			
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: **References/ Readings:**	1. Duhan, J.S., Gahlawat, S.K., Siwach, P., Salar. P.K (2016). Biotechnology: Prospects and Applications. Germany: Springer India. 2. Kim, S. (2019). Essentials of Marine Biotechnology. Germany: Springer International Publishing. 3. Murray, J. D., McGloughlin, M. M. (2005). Transgenic Animals in Agriculture. India: New India Publishing Agency. 4. Slater, A., Scott, N.W., & Fowler, M.R. (2008). Plant Biotechnology: The Genetic Manipulation of Plants (2nd ed.). Oxford University Press. United Kingdom. 5. Stewart Jr., C.N. (2025). Plant Biotechnology and Genetics: Principles, Techniques, and Applications. Wiley, United States 6. Verma, A.S., & Singh, A. (Eds.) (2020). Animal Biotechnology: Models in Discovery and Translation (2nd ed.). Academic Press, United States			
	Scientific journals: Plant Biotechnology Journal, Journal of Biotechnology, Animal Biotechnology, Biotechnology Advances, Frontiers in Bioengineering and Biotechnology, Marine Biotechnology, Frontiers in Marine Science.			
Web Resources:	1. http://www.fao.org/biotech 2. https://www.ncbi.nlm.nih.gov/books 3. https://epgp.inflibnet.ac.in 4. https://www.ncbi.nlm.nih.gov/pmc/			

Title of the Course	Lab V: Recombinant DNA Technology and Bioprocess Technology
Course Code	GBT-5010
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	MBT-5000, MBT-5002	
Course Objectives:	The students will • Understand cloning strategies and expression of foreign genes • Setting up reactions for DNA manipulation. • To interpret the results of DNA manipulation studies and use • Learn appropriate tools for the validation of recombinant DNA.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Execute plasmid DNA isolation, restriction mapping, PCR techniques, and recombinant screening.	PSO1, PSO8
	CO 2. Evaluate RT-PCR, real-time PCR, and affinity-based recombinant protein purification	PSO1, PSO8,

	CO 3. Design CRISPR-based vectors for mutagenesis, demonstrating gene editing applications.		PSO1, PSO7 PSO8,	
	CO 4. Describing the designs and operational principles of a bioreactor and demonstrating the ability to monitor the bioprocess data.		PSO4, PSO8	
	CO 5. Executing fermentation protocols for the production of industrially important bioproducts using submerged and solid substrate fermentation technology.		PSO4, PSO8	
	CO 6. Designing an integrated bioprocess workflow by combining the upstream and downstream processing approaches.		PSO4, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1.1 Plasmid DNA isolation 1.2 Restriction mapping 1.3 PCR amplification 1.4 Reverse transcriptase PCR 1.5 Real-time PCR 1.6 Cloning and ligation, and selection /screening of recombinants 1.7 Cloning in expression vectors 1.8 Purification of recombinant proteins by affinity, 1.9 Tutorial on designing CRISPR-based vectors for mutagenesis	**30**	CO1, CO2, CO3	K1, K2, K3, K4, K5, K6
Module 1:	2.1 Bioreactor Design and Bioprocess Monitoring 2.2 Production of model bioproducts using Fermentation technology (Submerged fermentation): Alcohol, lactic acid, citric acid, antibiotics; Solid substrate fermentation: Mushroom cultivation 2.3 Fermentation using agro-industrial waste 2.4 Preparation of an edible fermented product	**30**	CO4, CO5, CO6	K2,K3,K4, K5,K6

	2.5 Scale up operations and Yield optimisation: Effect of different parameters and Response surface methodology 2.6 Downstream processing and product recovery: Bio separations, cell or product harvesting (Centrifugation and filtration) 2.7 Analytical techniques for purifications and fermentation monitoring: Column chromatography, HPLC, Spectrophotometry.			
Pedagogy:	Hands-on experiments in the laboratory, online videos.			
References/ Readings:	1. S. Carson, *Manipulation and expression of recombinant, DNA a laboratory manual* Elsevier Academic Press, 2006. 2. M.R Green and J. Sambrook, *Molecular Cloning: A Laboratory Manual* Three-volume CSH Press, 2012. 3. J.S. Vennison, *Laboratory Manual for GENETIC ENGINEERING*, PHI Learning, 2009. 4. Stanbury, P. F., Whitaker, A., & Hall, S. J. *Principles of Fermentation Technology*. Elsevier (2017). 5. Shuler, M. L., & Kargi, F. *Bioprocess Engineering: Basic Concepts*. Pearson, 2017. 6. Doran, P. M. *Bioprocess Engineering Principles*. Academic Press, 2013. 7. Crueger, W., & Crueger, A. *Biotechnology: A Textbook of Industrial Microbiology*, Panima Publishing, 2017. 8. Waites, M. J., Morgan, N. L., Rockey, J. S., & Higton, G. *Industrial Microbiology: An Introduction*, Wiley-Blackwell, 2009. 9. Demain, A. L., & Sanchez, S. *Manual of Industrial Microbiology and Biotechnology* (3rd ed.). ASM Press, 2009.			

Title of the Course	Lab VII: Cell and Tissue Culture
Course Code	MBT-5011
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To gain a comprehensive understanding of the growth and development of plants *in vitro*. • To understand the fundamentals of animal cell culture, and the growth and maintenance of animal cells lines under aseptic conditions.	
Course Outcomes:		**Mapped to PSO**
	CO 1. They will get a basic understanding of the media and growth parameters required for the culture of plant tissue and animal cell lines.	PSO1, PSO2
	CO 2. The students will understand the basic concepts of pluripotency and totipotency in cell and tissue culture.	PSO2, PSO2
	CO 3. They shall learn to grow and maintain plant and animal cells/explants under aseptic conditions.	PSO1, PSO2, PSO6

	CO 4. The students will be exposed to modern techniques of plant propagation through Somatic embryogenesis and cell suspension culture.		PSO1, PSO2, PSO6	
	CO 5. Student will learn about the precaution taken, safety protocol, contamination identification in plant and animal cell culture		PSO1, PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Preparation of starting material (Biosafety cabinet, • solutions, media, cell sample etc.). • Thaw and culture, sub-culture, maintenance • Contamination check and • Precautions (Bacterial, fungal and mycoplasma test based on staining/PCR) • Confluency check, total cell count, live/dead staining and counting • Animal cell culture: Secondary cell culture CHO, HeLa and non-cancerous cell lines HEK293, COS-7, MDCK etc. • Cell stock preparation (glycerol stock), storage, freezing • Transfection and co-transfection: Calcium phosphate method and Lipofection • Cell fixation and staining: Immunolabeling, mounting, microscopy imaging.	**30**	CO1, CO2, CO3, CO4, CO5	K3, K4, K5
/Module 2:	• Tissue culture media preparation, contamination and precautions in plant tissue culture • Callus induction from different explants such as rice and carrot • Plantlet regeneration. • Somatic embryogenesis • Single cell suspension. • Protoplast isolation	**30**	CO1, CO2, CO3, CO4, CO5	K3, K4, K5
Pedagogy:	Hands-on experiments in the laboratory, online videos, and demonstrations.			

References/ Readings:	1. H. Sherathiya, Practical manual for Plant Tissue Culture: Basic Techniques of Plant Tissue Culture and Molecular Biology. Grin Verlag, 2013. 2. I.R. Freshney and A. Capes-Davis, Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Wiley Blackwell Publisher, 2021. 3. I.R. Freshney and J.R.W. Masters, Animal cell culture – A Practical Approach Oxford University Press, 2000. 4. R. Smith, Plant tissue culture Techniques and experiment. Academic Press, 2012.
Web Resources:	1. Animal Component–Free Cell Culture Media | ATCC 2. lebt108.pdf

Discipline Specific Elective Courses

Title of the Course	IPR, Biosafety and Bioethics
Course Code	MBT-5207
Number of Credits	3
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide basic knowledge on intellectual property rights and their implications in biological research and product development. • To learn biosafety and risk assessment of products derived from biotechnology and the regulation of such products. • To become familiar with ethical issues in biological research. • To learn the consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing, and GMOs	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the rationale for and against IPR and especially patents;	PSO5, PSO6

	CO 2. Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations		PSO5, PSO6	
	CO 3. Understand different types of intellectual property rights		PSO5, PSO7	
	CO 4. Gain knowledge national and international regulations of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of GMOs		PSO1, PSO5, PSO6	
	CO 5. Describe the major competing ethical theories and apply ethical theory to contemporary moral issues that arise out of recent developments in the life sciences that affect public policy.		PSO5, PSO6	
	CO 6. Analyze and assess moral beliefs about abortion, human reproduction, decisions of life and death, mental illness and other related issues.		PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Different types of IP: patents, trademarks, copyright, industrial design, traditional knowledge, geographical indications, Trade Secrets. • Basics of patents: types of patents; • Concept of 'prior art': invention in context of "prior art"; • Precautions before patenting-disclosure/non disclosure • Patent application- forms and guidelines, fee structure, time frames; • Types of patent applications: provisional and complete specifications; • PCT and conventional patent applications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; • Patent databases - IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; • WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) • International framework for the protection of IP	**15**	CO1, CO2, CO3	K1 K2 K3 K4 K5

	• National Bio-diversity Authority (NBA) and other regulatory bodies, protection of new GMOs; • History of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; • Country-wise patent searches (USPTO, EPO, India); analysis and report formation. • International patenting-requirement, procedures and costs; financial assistance for patenting • Publication of patents-gazette of India, status in Europe and US; • Patent infringement- meaning, scope, litigation, case studies and examples; • Commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists university/organizational rules in India and abroad, collaborative research - backward and forward IP; • Benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.			
Module 2:	• Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals. • Definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools. • International regulations – Cartagena protocol; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field	**15**	CO4	K1 K2 K3 K4 K5

	trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labelling – Food Safety and Standards Authority of India (FSSAI).			
Module 3:	• Introduction, ethical conflicts in biological sciences - interference with nature Bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis genetic screening, gene therapy, transplantation. • Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare • Scientific Misconduct and Publication ethics. • Agricultural and environmental ethics - Genetically engineered food, environmental risk, labelling and public opinion. • Sharing benefits and protecting future generations • Protection of environment and biodiversity • Biopiracy	**15**	CO5, CO6	K1 K2 K3 K4 K5
Pedagogy:	Lectures, tutorials, Case studies, assignments			
Texts:	1. Bently, L., & Sherman, B. (2008). *Intellectual property law*. Oxford University Press, **United Kingdom**. 2. Bently, L. (2008). *Intellectual property law*. Oxford University Press, **United Kingdom**. 3. Cook, T. M. (2007). *A user's guide to patents*. Tottel Publishing, **United Kingdom**. 4. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2009). *An overview of general divisions*. Retrieved from https://www.isaaa.org/ 5. EFSA Panel on Genetically Modified Organisms. (2010). Problem formulation in the environmental risk assessment for genetically modified plants. *Transgenic Research, 19*(3), 425–436. https://doi.org/10.1007/s11248-009-9321-9 6. Fleming, D. O., & Hunt, D. L. (2000). *Biological safety: Principles and practices*. ASM Press, **United States**. 7. Ganguli, P. (2001). *Intellectual property rights: Unleashing the knowledge economy*. Tata McGraw-Hill Publishing, **India**.			

	8. Grubb, P. W., & Thomsen, P. L. (2010). *Patents for chemicals, pharmaceuticals and biotechnology: Fundamentals of global law, practice and strategy*. Oxford University Press, **United Kingdom**. 9. Rajmohan, J. (2006). *Biosafety and bioethics*. Gyan Publishing House, **India**. 10. Greif, F. K., & Merz, J. F. (2007). *Current controversies in the biological sciences: Case studies of policy challenges from new technologies*. MIT Press, **United States**. 11. Keith, F. (2000). *CRC handbook of laboratory safety*. CRC Press, **United States**. 12. Kuhse, H. (2010). *Bioethics: An anthology*. Blackwell Publishing, **United Kingdom**. 13. Laws. (2007, October). *Snow White Publication*, **India**. 14. Singh, K. (1993). *Intellectual property rights in biotechnology: A status report*. Biotech Consortium India, **India**. 15. Sreenivasulu, N. S., & Raju, C. B. (2008). *Biotechnology and patent laws: Patenting living beings*. Manupatra Publishers, **India**. 16. Wegner, H. (1994). *Patent law in biotechnology, chemicals & pharmaceuticals*. Stockton Press, **United States**. 17. World Health Organization. (2004). *Laboratory biosafety manual* (3rd ed.). WHO Press, **Switzerland**. 18. World Intellectual Property Organization (WIPO). Retrieved from https://www.wipo.int/ (**Switzerland**) 19. World Trade Organization (WTO). Retrieved from http://www.wto.org (**Switzerland**)
References/ Readings:	1. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/ 2. Recombinant DNA Safety Guidelines, Department of Biotechnology, Ministry of Science and Technology, Govt. of India, 2017. Retrieved from https://dbtindia.gov.in/ 3. National Biodiversity Authority. http://www.nbaindia.org 18. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI.
Web Resources:	1. http://www.wipo.int 2. International Union for the Protection of New Varieties of Plants. http://www.upov.int 3. National Portal of India. http://www.archive.india.gov.in

Title of the Course	Lab VIII: IPR database, Patent drafting, and Bioethics
Course Code	MBT-5208
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	MBT-5207	
Course Objectives:	focusing on IPR databases, patent drafting, and bioethics would encompass practical exercises, real-world case studies, and hands-on drafting of patent applications, while also exploring ethical considerations within the field along with discussions on ethical dilemmas in bioethics.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand and apply IPR principles	PSO5, PSO6
	CO 2. Manage IPR databases	PSO5
	CO 3. Develop patent drafting skills	PSO5, PSO6
	CO 4. Comprehend bioethical issues in IPR and apply IPR principles in practical scenarios	PSO6

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	• IPR databases: Patent databases, their features, and usage; Patent Searching Techniques, searching for patents based on keywords, inventors, and patent numbers, Conducting thorough prior art searches for a given invention. • Analysis of search results: Identifying relevant prior art and understanding its significance. • Prior Art Analysis: Preparing prior art analysis reports for various inventions. • Patent Drafting: Drafting a basic patent application for a hypothetical invention • Drafting Claims: Drafting claims for various inventions, including those with multiple embodiments. • Patent Drafting Techniques: Drafting and revising patent applications for real-world inventions. • Bioethics: Analyzing case studies involving bioethical dilemmas in patenting inventions, Analyzing the ethical implications of patenting inventions with global impact.	**30**	CO1, CO2, CO3, CO4	K2 K3 K4 K5 K6
Texts:	Indian Patent Law and Practice" by K.C. Kankanala, A.K. Narasani, and V. Radhakrishnan. "WIPO Patent Drafting Manual" and "Patent Application Drafting: A Practical Guide" by Morgan D. Rosenberg			
References/ Readings:	Manual Of Patent Practice And Procedure The Patent Office, India. https://www.ipindia.gov.in/writereaddata/Portal/IPOGuidelinesManuals/1_59_1_15-wo-ga-34-china.pdf			
Web Resources:	1. World Intellectual Property Organization (WIPO). (n.d.). PatentScope. Retrieved from https://www.wipo.int/webdb/en/ 2. https://www.uspto.gov/ 3. https://patents.google.com/ 4. Official website of Intellectual Property India			

Title of the Course	Systems Biology
Course Code	MBT-5209
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	MBT-5000, MBT-5201	
Course Objectives:	• Introduce systems biology principles, network modeling, and dynamic simulation approaches to understand biological complexity across scales. • Equip students with practical skills to analyze and integrate multi-omics data for reconstructing and interpreting biological networks in health, agriculture, and biotechnology.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the core concepts of systems biology and distinguish between reductionist and systems-level approaches.	PSO1, PSO3
	CO 2. Analyze the structure and properties of biological networks using topological descriptors such as degree, centrality, and modularity.	PSO3, PSO4
	CO 3. Develop and simulate basic mathematical models of biological systems using deterministic, stochastic, and logic-based frameworks.	PSO3, PSO5

	CO 4. Perform network reconstruction and visualization using public databases and tools.		PSO2, PSO4	
	CO 5. Process and analyze multi-omics datasets using standard pipelines for genomics, transcriptomics, proteomics, and metabolomics.		PSO2, PSO3	
	CO 6. Integrate multi-omics data to construct biological networks and interpret their functional implications through case studies in health and agriculture.		PSO3, PSO4, PSO6	
Content:	GBT-5000, GBT-5201	**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Systems Biology:** Systems-level understanding vs. reductionism**,** Historical context and paradigm shift**,** Applications in medicine, agriculture, and synthetic biology. **Biological Networks:** Architecture and Properties, gene regulatory, protein–protein interaction, metabolic, signaling, Components: nodes, edges, hubs, modules, motifs, Topological properties: degree distribution, clustering, centrality, random vs. scale-free networks. **Network Dynamics and Emergent Properties:** Feedback loops, noise, robustness, bistability, modularity, oscillations, Time-scale separation and adaptation. **Modeling Frameworks:** Deterministic vs. stochastic modelling, Boolean and logic-based models, ODE-based models (basics), Constraint-based modeling: flux balance analysis (FBA). **Tools and Databases for Network Analysis:** Databases: STRING, BioGRID, IntAct, Reactome, Visualization: Cytoscape, Gephi, Network reconstruction from transcriptome/proteome data.	**15**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5
Module 2:	**High-throughput Omics Overview:** Genomics, transcriptomics, proteomics, metabolomics, epigenomics, interactomics, Platforms: NGS, MS, LC-MS, NMR, ATAC-seq, ChIP-seq. **Data Processing Pipelines:** Genomics: sequencing (Sanger, NGS, PacBio/Nanopore), assembly, annotation, variant calling, Transcriptomics: RNA-Seq (HISAT2, STAR, DESeq2), Proteomics: MS workflows, quantification, PTM	**15**	CO4, CO5, CO6	K1, K2, K3, K4, K5, K6

	analysis, Metabolomics: GC-MS/LC-MS, preprocessing, interpretation, Epigenomics: bisulfite seq, ChIP-Seq, ATAC-seq basics. **Network Construction from Omics Data:** Co-expression and interaction networks, Graph measures: centrality, modularity, motifs, Specialized networks (e.g., primary vs. secondary metabolism). **Multi-Omics Integration:** Challenges: scale, heterogeneity, normalization, Tools: OmicsNet, MixOmics, PaintOmics, Standards: FAIR principles, Case studies in multi-omics integration.			
Module 3:	**Biological Pathways and Simulation:** Pathway types: metabolic, regulatory, signaling, Databases: KEGG, Reactome, WikiPathways, Modeling dynamics: ODEs, stochastic models (Gillespie), Simulation tools: COPASI, CellDesigner. **Gene Regulatory and Co-expression Networks:** TFs, cis-regulatory elements, target genes, Network inference: Pearson/Spearman, mutual information (ARACNe, CLR), ML-based (LASSO, GENIE3), Module detection: WGCNA, Functional enrichment: GO, KEGG. **Metabolic Modeling and Engineering:** Primary vs. secondary metabolism, Constraint-based modeling: COBRA toolbox, Pathway Tools, Applications in metabolic engineering and synthetic biology. **Applications and Case Studies:** Disease systems biology (cancer, diabetes), Host-pathogen interaction modelling, Plant systems biology (stress responses, flowering), Microbiome and microbial consortia modelling, Emerging fields: single-cell systems biology, spatial omics, Classic case studies: *E. coli* metabolism, yeast cell cycle, immune signaling dynamics.	**15**	CO2, CO3, CO5, CO6	K3, K4, K5, K6
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: **References/ Readings:**	1. Alon, U. (2019). *An Introduction to Systems Biology: Design Principles of Biological Circuits* (2nd ed.). Chapman and Hall/CRC. United States 2. Kitano, H. (Ed.). (2001). *Foundations of Systems Biology.* MIT Press. United States 3. Klipp, E., Liebermeister, W., Wierling, C., Kowald, A., & Herwig, R. (2016). *Systems Biology: A Textbook* (2nd ed.). Wiley-VCH. Germany			

	4. Kriete, A. (2013). Computational Systems Biology: From Molecular Mechanisms to Disease. Netherlands: Academic Press. 5. Palsson, B. Ø. (2015). *Systems Biology: Constraint-based Reconstruction and Analysis* (2nd ed.). Cambridge University Press. England
	Supplementary Reading Scientific journals: BMC Systems Biology, Frontiers in Systems Biology.
Web Resources:	1. https://www.ebi.ac.uk/biomodels/ 2. https://www.omicsnet.ca/ 3. https://string-db.org/

Title of the Course	Lab IX: Practical Approaches to Systems Biology
Course Code	MBT-5210
Number of Credits	1
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	MBT-5000, MBT-5201, MBT-5202	
Course Objectives:	To equip students with hands-on skills in modeling, simulating, and analyzing dynamic biological systems and networks using experimental and publicly available data.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply simulation tools to model stress-response and oscillatory dynamics in biological systems.	PSO3, PSO5
	CO 2. Analyze gene expression data to construct gene regulatory networks and interpret regulatory interactions.	PSO3, PSO4
	CO 3. Evaluate metabolic network properties across species to assess complexity and identify central biochemical nodes.	PSO3, PSO4

	CO 4. Create pathway enrichment visualizations and simulate ligand-receptor binding to explore functional implications in systems-level contexts.		PSO3, PSO4, PSO6	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module:	1. Environmental perturbation and stress-response modelling using ROS or stress-related marker. 2. Measurement of oscillatory behaviour in biological systems. 3. Construction of a gene regulatory network (GRN) from publicly available expression data. 4. Compare metabolic networks for two or more species and compare network complexity or central enzymes. 5. Simulate drug-receptor binding kinetics to model ligand-receptor interaction. 6. Pathway enrichment and data visualization.	**30**	CO1, CO2, CO3, CO4	K3, K4, K5, K6
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion			
Texts: References/ Readings:	1. Alon, U. (2019). *An Introduction to Systems Biology: Design Principles of Biological Circuits* (2nd ed.). Chapman and Hall/CRC. United States 2. Emili, A., Cagney, G. (2016). *Network Biology: Methods and Applications*. Humana Press. 3. Kitano, H. (Ed.). (2001). *Foundations of Systems Biology*. MIT Press. United States 4. Klipp, E., Liebermeister, W., Wierling, C., Kowald, A., & Herwig, R. (2016). *Systems Biology: A Textbook* (2nd ed.). Wiley-VCH. Germany 5. Palsson, B. Ø. (2015). *Systems Biology: Constraint-based Reconstruction and Analysis* (2nd ed.). Cambridge University Press. England			
Web Resources:	1. **BioModels Database** – https://www.ebi.ac.uk/biomodels/ 2. **Cytoscape** – https://cytoscape.org/ 3. **COPASI (COmplex PAthway SImulator)** – https://copasi.org/ 4. **MetaboAnalyst** – https://www.metaboanalyst.ca/ 5. **Gene Expression Omnibus (GEO)** – https://www.ncbi.nlm.nih.gov/geo/			