गोंय विद्यापीठ
ताळगांव पठार,
गोंय - ४०३ २०६
फोन : + ९१ - ८६६९६०९०४८

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(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP/2025-26/110 Date: 01.06.2026

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP/2025-26/349 dated 20.08.2025

In supersession to the above referred Circular, the syllabus of Semester III & IV of the **Master of Science in Marine Biotechnology** Programme approved by the Standing Committee of the Academic Council in its meeting held 24th & 25th November 2025, is attached.

The syllabus of Semester I & II approved earlier by the Standing Committee of the Academic Council in its meeting held on 24th & 25th June 2025, is also 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 V LAWANDE Digitally signed by ASHWIN V LAWANDE Date: 2026.06.01 14:50:41 +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:

3. Chairperson, BoS in Biotechnology, Goa University.
4. Programme Director, M.Sc. Marine Biotechnology, Goa University.
5. Controller of Examinations, Goa University.
6. Assistant Registrar Examinations (PG), Goa University.
7. 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.

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	3T	400
2	**MBT-5001**	Immunology and marine pathogenesis	3T	400
3	**MBT-5002**	Bioanalytical Techniques and Applications	3T	400
4	**MBT-5003**	Oceanography and Marine Bioresources	3T	400
5	**MBT-5004**	Lab I: Molecular Biology, Immunodiagnostics & Marine Pathogenesis	2P	400
6	**MBT-5005**	Lab II: Bio-analytical Tools and Oceanographic Techniques	2P	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	3T	400
2	**MBT-5202**	Lab III: Computational Biology & Data Analysis	1P	400
3	**MBT-5203**	Environmental Biotechnology and Sustainability	3T	400
4	**MBT-5204**	Lab IV: Environmental Biotechnology	1P	400
5	**MBT-5205**	Cell and Developmental Biology	3T	400
6.	**MBT-5206**	Lab V: Cell Biology	1P	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	3T	500
2	**MBT-5007**	Recombinant DNA Technology	3T	500
3	**MBT-5008**	Cell and Tissue Culture: Techniques and Applications	3T	500
4	**MBT-5009**	Plant and Animal Biotechnology	3T	500
5	**MBT-5010**	Lab VI: Recombinant DNA Technology and Bioprocess Technology	2P	500
6	**MBT-5011**	Lab VII: Cell and Tissue Culture	2P	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	3T	400
2	**MBT-5208**	Lab VIII: IPR database, Patent drafting, and Bioethics	1P	400
3	**MBT-5209**	Systems Biology	3T	400
4	**MBT-5210**	Lab IX: Practical Approaches to Systems Biology	1P	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.

SEMESTER III				
Research Specific Elective (RSE) Courses (12 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**MBT-6000**	Bioentrepreneurship	2T	500
2	**MBT-6001**	Biostatistics in Biological Sciences	2T	500
3	**MBT-6002**	Integrated Genomics and Proteomics	2T	500
4	**MBT-6003**	Lab in Omics	2P	500
5	**MBT-6004**	Internship*	2P	500
6	**MBT-6005**	Satellite Applications in Marine Studies	2T	500
7	**MBT-6006**	Marine Pharmaceuticals and Pharmacology	2T	500
8	**MBT-6007**	Lab in Marine Pharmaceuticals and Pharmacology	2P	500
9	**MBT-6008**	Research Methodology	4T	500
Total Credits for RSE Courses in Semester III			**16**	
Discipline Specific Vocational Elective (DSVE) Courses (8 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**MBT-6401**	Seafood Processing Technology [T+P]	2T+2P	500
2	**MBT-6402**	Algal Biotechnology and Bioeconomy [T+P]	2T+2P	500
3	**MBT-6403**	Aquaculture Biotechnology [T+P]	2T+2P	500
Total Credits for DSVE Courses in Semester III			**12**	
Total Credits in Semester III			**20**	

*(Internship is to be completed during the summer break after the second semester)

Discipline Specific Dissertation (DSD) (40 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**MBT-6501**	Dissertation	**40**	**500**

SEMESTER IV				
Generic Elective (GE) Courses (20 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**MBT-6201**	Blue Economy	2T	500
2	**MBT-6202**	Trends in Sustainable Waste Resource Management	4T	500
3	**MBT-6203**	Model Organisms for Genomic Research	4T	500
4	**MBT-6204**	Modern Agricultural Techniques and Livestock Management	4T	500
5	**MBT-6205**	Scuba Diving	2T	500
6	**MBT-6206**	Microbiome	4T	500
7	**MBT-6207**	Marine Bioremediation and Pollution Monitoring	4T	500
Total Credits for GE Courses in Semester IV			**24**	

Discipline Specific Dissertation (DSD)/ Internship (20 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**MBT-6502**	Dissertation	20	500
Total Credits in Semester IV			**20**	

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			

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Title of the Course	Basics 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			

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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/

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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.

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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

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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

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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.			

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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.			

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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

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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

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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/-

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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/-			

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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.			

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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			

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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
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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.

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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	PSO1, PSO2

	industrially important microorganisms, as well as the formulation of culture media for bioprocesses.			
	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	**15**	CO2, CO3	K2, K3, K4, K5

	• alcohol (beer), biopharmaceuticals (vaccines) • organic acids (citric acid) • 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

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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.

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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			

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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/			

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Title of the Course	Lab VI: 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.			

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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

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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

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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			

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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/

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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/			

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SEMESTER III

Research Specific Elective (RSE) Courses

Title of the Course	Bioentrepreneurship
Course Code	MBT-6000
Number of Credits	02
Theory/Practical	Theory
Level	400
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	The course aims: • To introduce the fundamentals of bioentrepreneurship and the qualities of a successful biotech entrepreneur. • To develop skills for innovation, startup creation, and navigating legal and regulatory frameworks in biotech ventures. • To equip students with the ability to prepare business plans, manage finances, and explore funding options for bioventures.

	• To build competency in marketing, team management, and strategic leadership within the biosciences industry.			
Course Outcomes:	By the end of the course, students will be able to:		**Mapped to PSO**	
	CO 1. Demonstrate understanding of bioentrepreneurship concepts and identify opportunities in the life sciences sector.		PSO 4, PSO 6, PSO 7	
	CO 2. Apply innovation tools and legal knowledge to design and initiate a biotech startup.		PSO 5, PSO 6, PSO 7	
	CO 3. Prepare and evaluate business plans with financial forecasting and funding strategies.		PSO 6, PSO 7	
	CO 4. Design marketing strategies and apply leadership skills for managing teams in biotech startups.		PSO 6, PSO 8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Foundations of Entrepreneurship in Biosciences** ● Definition and scope of bioentrepreneurship ● Mission, vision, and qualities of a bioentrepreneur ● Dos and Don'ts of entrepreneurship **Innovation and Start-up Creation in Biotech** ● Design Thinking and Design-Driven Innovation ● Systems thinking and Open Innovation ● How to start a biotech startup? ● Legal and statutory requirements (IPR, GST, Labor law, E-business setup and management) **Business Plan Development for Bioventures** ● Preparing a business proposal for financial institutions ● Approaching banks and funding sources ● Budgeting, cash flow management, and financial forecasting **Financing Bio-Startups**	**15**	CO1, CO2, CO3	K1, K2, K3, K4, K5, K6

	● Bootstrapping, crowdfunding, angel investors, venture capital, debt financing ● Incubation and acceleration ● Government schemes and incentives for biotech entrepreneurs and startup **Financial Planning and Analysis** ● Negotiations with financiers and banks ● Understanding financial statements: Profit & Loss, Balance Sheet, Cash Flow ● Cost-volume-profit & Break-even analysis ● Capital budgeting			
Module 2:	**Marketing Management in Biotech Startups** ● Assessing market demand for biotech products ● Market segmentation and trend prediction ● Customer needs and market gaps ● Packaging, branding, and market linkages ● Developing distribution channels ● Pricing strategies and competition analysis ● Advertising and promotion ● Services marketing and dispute resolution **Team Building and Leadership in Bioventures** ● Building interdisciplinary teams ● Role of scientists, business experts, and legal advisors ● Leadership and managerial skills for scientists and entrepreneurs ● Organizational structures: pros and cons ● Team building and teamwork in startups ● Performance appraisal and reward systems ● Navigating external environmental changes ● Crisis management and global strategic thinking	**15**	CO4	K2, K3, K4, K5, K6

Pedagogy:		
Texts:	1. D. J. Adams, & J. C. Sparrow, Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion, 2008. 2. A. J. Byrne, World Changers: 25 Entrepreneurs Who Changed Business as We Knew it. New York: Penguin, 2011. 3. Jordan, J. F. Routledge.., Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press, 2014. 4. V. Desai, The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House, 2009. 5. J. Lynn, The Entrepreneur's Almanac: ascinating igures, Fundamentals and Facts at your Fingertips. Canada: Entrepreneur Media Inc, 2007. 6. D. Ramsey, Entre Leadership: 20 Years of Practical Business Wisdom from the Trenches. New York: Howard Books, 2011 7. C. D. Shimasaki, Biotechnology Entrepreneurship: Starting, Managing, 2014.	
References/ Readings:	1. Juma, C. (2016). *Innovation and its enemies: Why people resist new technologies*. Oxford University Press. 2. Kotler, P., & Keller, K. L. (2016). *Marketing management* (15th ed.). Pearson. 3. Moors, P. A. A. (Ed.). (Year). *Business planning for biotechnology startups*. [Publisher]. 4. Prins, H. H. T., & Breugelmans, C. (Year). *Biotechnology business: Planning, finance, and management*. [Publisher]. 5. Ries, E. (2011). *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses*. Crown Business. 6. Shimasaki, C. D. (2014). *Biotechnology entrepreneurship: Starting, managing, and leading biotech companies* (2nd ed.). Academic Press.	
Web Resources:	1. https://www.nature.com/bioent/ 2. https://www.bio.org/ 3. https://www.startupindia.gov.in/ 4. https://www.standupmitra.in/	

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GOA UNIVERSITY
गोवा विश्वविद्यालय
Knowledge is Divine

Title of the Course	Biostatistics in Biological Sciences
Course Code	MBT-6001
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To introduce the fundamental concepts and applications of biostatistics in biological research. • To develop an understanding of data collection, organisation, and descriptive statistical analysis in biological contexts. • To apply probability, statistical inference, and hypothesis testing for interpreting biological data. • To train students in using statistical tools and experimental design for scientific data analysis and decision-making.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Define and explain the basic concepts, role, and scope of biostatistics in biological sciences.	PSO1, PSO3
	CO 2. Classify types of data, explain probability concepts, and describe data collection and sampling techniques.	PSO2, PSO3

	CO 3. Apply descriptive and inferential statistical tools (t-test, ANOVA, chi-square, etc.) to analyse biological data.		PSO1, PSO2, PSO3	
	CO 4. Analyse biological datasets using correlation, regression, and multivariate methods such as PCA and cluster analysis.		PSO3, PSO4, PSO8	
	CO 5. Evaluate hypotheses, interpret statistical results, and select appropriate statistical approaches for experimental data.		PSO1, PSO3, PSO7	
	CO 6. Design and statistically analyse biological experiments using computational and interpret omics data		PSO1, PSO3, PSO4, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	• Fundamentals of Biostatistics: Basic concepts, role and scope of Biostatistics, measurement scales, types of data and data collection, sampling and statistical inference, concepts of probability and probability distribution and its application in biological sciences, scientific method and designing of experiments. • Descriptive statistics: Frequency distribution of grouped data, Measures of central tendency and dispersion • Hypothesis Testing: Concept of null and alternative hypotheses, Type I and Type II errors, power of the test. • Parametric tests: t-test (one-sample, independent, paired), ANOVA (one-way, two-way, repeated measures), Post hoc tests (Tukey's, Dunnett's, Bonferroni), Confidence intervals and effect size.	**15**	CO1 to CO6	K1, K2, K3, K4, K5, K6
Module 2:	• Non-parametric tests: Chi-square test, Mann–Whitney U, Kruskal–Wallis, Wilcoxon signed-rank • Correlation and regression (simple and multiple) • Multivariate methods: Principal Component Analysis (PCA), Cluster Analysis, Discriminant Analysis, Canonical Correspondence Analysis (CCA). • Advanced Statistical Techniques: Introduction to Excel and software for statistical analysis • Statistical approaches in genomics, transcriptomics, and proteomics. • Design and statistical analysis of a biological experiment	**15**	CO3, CO4, CO5, CO6	K3, K4, K5, K6

Pedagogy:	Lectures, tutorials, assignments
Texts: **References/ Readings:**	1. Bruce, P., Bruce, A., & Gedeck, P. (2020). *Practical statistics for data scientists* (2nd ed.). O'Reilly Media. 2. Daniel, W. W., & Cross, C. L. (2018). *Biostatistics: A foundation for analysis in the health sciences* (11th ed.). Wiley. 3. Le, C. T. (2003). *Introductory biostatistics*. Wiley-Interscience. 4. Mahajan, B. K. (2018). *Methods in biostatistics: For medical students and research workers*. Jaypee Brothers Medical Publishers. 5. Montgomery, D. C. (2019). *Design and analysis of experiments* (10th ed.). Wiley. 6. Pagano, M., & Gauvreau, K. (2018). *Principles of biostatistics* (2nd ed.). CRC Press. 7. Rosner, B. (2015). *Fundamentals of biostatistics* (8th ed.). Cengage Learning. 8. Rastogi, V. B. (2009). *Fundamentals of biostatistics*. Ane Books Pvt. Ltd. 9. Shahbaba, B. (2012). *Biostatistics with R: An introduction to statistics through biological data*. Springer. 10. Thompson, J., & Mount, D. W. (2016). *Statistics for bioinformatics*. Springer. 11. Zar, J. H. (2010). *Biostatistical analysis* (5th ed.). Pearson Education.

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Title of the Course	Integrated Genomics & Proteomics
Course Code	MBT-6002
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To understand the structural and functional organization of prokaryotic and eukaryotic genomes**.** • To develop competence in the methodologies and analytical tools of genomics and proteomics**.** • To apply genomic and proteomic knowledge to biological, agricultural, and biomedical contexts**.**	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the structural organization and dynamics of prokaryotic, eukaryotic, and organellar genomes, including principles of DNA packaging and chromosomal territories.	PSO 1, PSO 3, PSO 8
	CO 2. Apply genetic, physical, and cytogenetic mapping techniques to locate and characterize genes using molecular markers and FISH-based approaches.	PSO 1, PSO 2, PSO 8

	CO 3. Retrieve and interpret genome sequence data from major online databases to analyze synteny, gene annotation, and evolutionary relationships.		PSO 1, PSO 3, PSO 8	
	CO 4. Demonstrate understanding of proteomic principles, including protein extraction, separation, identification, and quantification using gel-based and mass spectrometry-based methods.		PSO 1, PSO 2, PSO 3	
	CO 5. Analyze protein–protein, protein–DNA, and protein–RNA interactions, and evaluate post-translational modifications to infer functional and regulatory relationships.		PSO 1, PSO 3, PSO 8	
	CO 6. Assess and integrate genomic and proteomic data for applications in agriculture, health, and biotechnology, including biomarker discovery and drug target identification.		PSO 3, PSO 4, PSO 7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Genome Organization:** Overview of prokaryotic and eukaryotic genome organization, mitochondrial and chloroplast genomes, DNA packaging, topological domains, Genome compartment and chromosomal territories. **Genome Mapping and Techniques**: Principles and applications genetic and physical maps, Molecular markers for genetic mapping, Gene mapping approaches: Linkage analysis, Physical mapping, Cytogenetic techniques, DNA-FISH and RNA-FISH techniques, Synteny analysis across species **Genome Sequencing and Databases:** Human Genome Project and major genome sequencing projects in microbes, plants, and animals. Accessing and retrieving genome project information from online databases. **Analysis and Applications of Genomics:** Molecular markers in identification and classification of organisms, Genomic approaches to study evolution of eukaryotes. Determining gene location in genome sequences. Application of genomics in health and agriculture. Tracking emerging diseases and drug design using genomic data.	**15**	CO 1, CO 2, CO 3, CO 4	K2, K3, K4, K5
Module 2:	**Introduction and Fundamentals:** Definition, scope, and significance of proteomics. Relationship between genome and proteome; concept of the dynamic proteome. Sample preparation: protein extraction from different biological sources, protein solubilization, and fractionation.	**15**	CO 4, CO 5, CO 6	K1, K2, K3, K4, K5

	Proteomics Approach: Gel-based proteomics (1D and 2D-PAGE, isoelectric focusing, differential gel electrophoresis). Mass spectrometry-based proteomics, principles, instrumentation, MALDI-TOF, ESI-MS, LC-MS. Quantitative proteomics approaches (iTRAQ, SILAC, TMT, label-free quantification). **Functional and Interaction Proteomics:** Protein–protein interactions: co-immunoprecipitation, pull-down assays, Microscopy based approaches. Protein–DNA and protein–RNA interactions: EMSA, ChIP, RIP. Post-translational modifications (PTMs) analysis. **Proteome databases and applications:** Different type of proteome databases, tools for protein identification, quantification analysis. Current challenges in proteomics: complexity, dynamic range, reproducibility, and technical limitations. Clinical and biomedical applications: biomarker discovery, drug target identification, disease diagnostics.			
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion/ICT			
Texts: **References/ Readings:**	1. Brown, T. A. (2023). *Genomes 5*. CRC Press. 2. Liebler, D. (2013). *Introduction to proteomics: Tools for the new biology*. Humana Press. 3. Mount, D. W. (2004). *Bioinformatics: Sequence and genome analysis*. Cold Spring Harbor Laboratory Press. 4. Primrose, S. B., & Twyman, R. M. (2009). *Principles of genome analysis and genomics*. Wiley. 5. Speicher, D. W. (2004). *Proteome analysis: Interpreting the genome*. Elsevier Science. 6. Suhai, S. (2013). *Genomics and proteomics: Functional and computational aspects*. Springer. 7. Twyman, R. M. (2014). *Principles of proteomics*. Garland Science. 8. Watson, J. D. (2014). *Molecular biology of the gene*. Pearson.			
Web Resources:	1. https://www.genome.gov/27530225/free-online-tutorials-teach-anyone-how-to-use-genome-databases 2. https://www.ebi.ac.uk/pride/ 3. http://www.peptideatlas.org 4. https://www.proteomicsdb.org 5. https://iptgxdb.expasy.org 6. https://www.hsls.pitt.edu/obrc/index.php?page=proteomics			

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Title of the Course	Lab in Omics
Course Code	MBT-6003
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	Computational Biology & Data Analysis (GBT-5201) Lab in Computational Biology & Data Analysis (GBT-5202)	
Course Objectives:	• To develop hands-on proficiency in computational analysis of high-throughput omics datasets • To enhance data interpretation and communication skills through visualization and network-based analyses, facilitating biological insight extraction from complex omics datasets.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Perform transcriptome data analysis, including expression quantification, differential gene expression, and gene ontology–based functional enrichment to interpret biological significance.	PSO 1, PSO 3, PSO 8
	CO 2. Identify and analyze regulatory motifs and transcription factor binding sites to infer gene regulatory mechanisms using computational tools.	PSO 3, PSO 8, PSO 7
	CO 3. Conduct taxonomic and functional profiling of microbial communities through metagenomic data analysis and interpretation.	PSO 2, PSO 3, PSO 7

	CO 4. Process and interpret metabolomics, proteomics, and lipidomics datasets for the detection, quantification, and functional mapping of biomolecules across experimental conditions.		PSO 1, PSO 3, PSO 4	
	CO 5. Integrate and visualize multi-omics datasets using heatmaps, enrichment plots, and network visualization tools such as Cytoscape to reveal system-level biological insights.		PSO 3, PSO 7, PSO 8	
	CO 6. Apply multi-omics data analysis pipelines to address real biological questions related to gene regulation, metabolism, and microbial community dynamics.		PSO 3, PSO 7, PSO 8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Transcriptome** 1. Perform expression quantification of RNA-seq transcriptome datasets and identify differentially expressed genes between experimental conditions. 2. Gene Ontology (GO) Annotation and Functional Enrichment Analysis. **Functional Genomics** 3. Motif Enrichment Analysis for Regulatory Sequence Discovery. 4. Identification and Analysis of Transcription Factor Binding Sites (TFBS) in nucleotide sequences. **Metagenomics** 5. Taxonomic Profiling of Microbial Communities using metagenomic data.	**30**	CO 1, CO 2, CO 3	K3, K4 and K5
Module 2:	**Metabolomics** 1. To process and analyze metabolomics data using computational tools in order to detect, quantify, and interpret significant metabolic changes between experimental groups. 2. Pathway Mapping of Metabolites using KEGG/MetaboAnalyst **MS-proteomics** 3. Proteomic data analysis: peptide identification and quantification from MS demo dataset.	**30**	CO 4, CO 5, CO 6	K3, K4, K5 and K6

	Lipidomic 4. Computational Analysis of Lipidomics Data: Profiling, Differential Expression, Enrichment, and Network Mapping (LipidSig). **Omics Data visualization** 5. Heatmap Analysis for Visualization of Omics Data. 6. Network Visualization and Analysis using Cytoscape			
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion/ICT/Hands on-training			
Texts:	1. Arivaradarajan, P., & Misra, G. (2019). *Omics approaches, technologies and applications: Integrative approaches for understanding omics data*. Springer Nature Singapore. 2. Azad, R. K. (2024). *Transcriptome data analysis*. Springer. 3. Buffalo, V. (2015). *Bioinformatics data skills*. O'Reilly Media. 4. Imai, K., & Fong-Yau, S. L. (2013). *Quantitative proteome analysis: Methods and applications*. Jenny Stanford Publishing. 5. Ning, K. (2023). *Methodologies of multi-omics data integration and data mining: Techniques and applications*. Springer Nature Singapore. 6. Wehrens, R., & Salek, R. (2019). *Metabolomics: Practical guide to design and analysis*. CRC Press. 7. Winkler, R. (2022). *Processing metabolomics and proteomics data with open software: A practical guide*. Royal Society of Chemistry.			
References/ Readings:				
Web Resources:	1. https://melbournebioinformatics.github.io/MelBioInf_docs/tutorials/rna_seq_dge_basic/rna_seq_basic_tuxedo/ 2. http://geneontology.org 3. https://meme-suite.org 4. https://www.metaboanalyst.ca 5. https://www.genome.jp/kegg/tool/map_pathway2.html 6. https://www.ebi.ac.uk/pride/ 7. https://www.r-graph-gallery.com/heatmap.html 8. https://cytoscape.org			

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Title of the Course	Internship
Course Code	MBT-6004
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	The primary objectives is • To understand the agency as a system, and to develop an understanding and skills in working with specialized organization. • To impart student with "hands-on" experiences at a qualified place of employment (non-profit or governmental agency or private organizations) • To provide a potential impact to students' cognitive skills, knowledge, interests, and future career.	
Course Outcomes:	By the end of the Internship course, students will be able to:	**Mapped to PSO**
	CO 1. Demonstrate hands-on experience by engaging in daily work practices and responsibilities at a qualified organization (industry, research institution, non-profit, or government agency).	PSO1, PSO2, PSO3, PSO4, PSO6

	CO 2. Apply discipline-specific skills and knowledge under professional supervision, thereby enhancing readiness for employment in similar professional environments.			PSO1, PSO2, PSO3, PSO4, PSO5, PSO6
	CO 3. Gain exposure to diverse workforces and develop a broader understanding of career opportunities and professional pathways.			PSO1, PSO2, PSO3, PSO4, PSO5, PSO6
	CO 4. Establish constructive mentor–mentee relationships with supervisors/employers, fostering professional networking and personal growth.			PSO1, PSO2, PSO4, PSO5, PSO6
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
	Application of Knowledge and Skills o Integration of theoretical knowledge from the classroom with practical exposure in industrial or academic environments. o Observation and participation in job-related activities under the supervision of the host organization. **Professional Work Practices** o Adherence to organizational policies, work schedules, and professional ethics of the host agency. o Active involvement in daily operations, projects, and assigned responsibilities. **Documentation and Reporting** o Preparation of a structured internship report detailing tasks performed, skills acquired, and key learnings. o Certification of the report by the supervisor/Head of the host organization. o Submission of the report to the Program Director/Coordinator for evaluation.	60	CO1, CO2, CO3, CO4	K3, K4, K5
Pedagogy:	Theory, practical demonstrations, documentation/ tutorials/assignments			

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Title of the Course	Satellite Applications in Marine Studies
Course Code	MBT-6005
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To provide students with a fundamental understanding of remote sensing, GIS, and satellite systems relevant to marine studies. • To explain the principles and methods of deriving key oceanographic parameters from satellite data and their ecological significance. • To develop the ability to apply satellite-based information for addressing marine biotechnological applications such as HAB monitoring, aquaculture management, and pollution tracking. • To enable critical analysis and integration of satellite data with field and laboratory-based studies for sustainable marine resource management.	
Course Outcomes:	At the end of the course, students will be able to:	Mapped to PSO
	CO 1. Describe the fundamentals of remote sensing, GIS, and the various types of satellites and sensors used in ocean observation.	PSO 2, PSO 3

	CO 2. Explain the ecological significance of satellite-derived oceanographic parameters such as SST, chlorophyll-a, turbidity, and ocean color.		PSO 1, PSO 2, PSO 3	
	CO 3. Apply satellite-based data to monitor marine biotechnological phenomena such as HABs, aquaculture site selection, pollution tracking, and climate impacts.		PSO 2, PSO 4, PSO 7	
	CO 4. Evaluate satellite data integration with field observations to interpret marine case studies.		PSO 2, PSO 3, PSO 7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Satellite Applications in Marine Sciences** • Basics of remote sensing and GIS. • Types of satellites (polar orbital vs geostationary) and sensors relevant to ocean studies. • Overview of Indian and international oceanographic satellites (IRS, OCM, Oceansat, MODIS, Sentinel, etc.). • Significance of "blue remote sensing" for marine biotechnologists. **Satellite-derived Oceanographic Parameters** • Sea Surface Temperature (SST) and its importance in plankton productivity and aquaculture. • Ocean color and chlorophyll-a mapping: detecting phytoplankton biomass, HABs, identify productive zones. • Turbidity, suspended sediments, dissolved organic matter. • Altimetry and ocean currents: implications for larval dispersal and fisheries.	**15**	CO1, CO2	K1, K2, K3
Module 2:	**Applications in Marine Biotechnology** • Monitoring and prediction of Harmful Algal Blooms (HABs). • Supporting aquaculture: site selection, disease risk prediction, water quality. • Bioprospecting: linking ocean color with potential bioactive compound-rich	**15**	CO3, CO4	K3, K4, K5

	regions. • Tracking oil spills and marine pollution for bioremediation strategies. • Climate change and long-term ecosystem monitoring (impact on plankton, fisheries). • Integration of satellite data with in-situ measurements and lab studies. **Tools and Case Studies** • Introduction to freely available portals (NASA OceanColor, Copernicus Marine, INCOIS, NOAA). • Accessing chlorophyll/SST maps from online sources. • Case studies: HAB detection, aquaculture site mapping, pollution tracking. • Limitations of satellite data (cloud cover, spatial resolution, ground-truthing).			
Pedagogy:	Lectures/Tutorials/demonstration/hands on tools/ case studies/ seminars/class discussions			
Texts:	1. Gordon, H. R. (2019). *Physical principles of ocean color remote sensing*. Springer. 2. Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2014). *Remote sensing and image interpretation* (7th ed.). Wiley. 3. Liu, J. G., & Mason, P. J. (2016). *Image processing and GIS for remote sensing: Techniques and applications* (2nd ed.). Wiley-Blackwell. 4. Martin, S. (2014). *An introduction to ocean remote sensing*. Cambridge University Press. 5. Tang, D. L. (2011). *Remote sensing of the changing oceans*. Springer.			
References/ Readings:	1. Blount, T. R., Carrasco, A. R., Cristina, S., & Silvestri, S. (2022). Exploring open-source multispectral satellite remote sensing as a tool to map long-term evolution of salt marsh shorelines. *Estuarine, Coastal and Shelf Science, 266*, 107664. https://doi.org/10.1016/j.ecss.2022.107664 2. Fingas, M., & Brown, C. (2014). Review of oil spill remote sensing. *Marine Pollution Bulletin, 83*(1), 9–23. https://doi.org/10.1016/j.marpolbul.2014.03.059 3. Kavanaugh, M. T., Bell, T., Catlett, D., Cimino, M. A., Doney, S. C., Klajbor, W., … Siegel, D. A. (2021). Satellite remote sensing and the marine biodiversity observation network. *Oceanography, 34*(2), 62–79. https://doi.org/10.5670/oceanog.2021.214			

	4. Klemas, V. (2012). Remote sensing of algal blooms: An overview with case studies. *Journal of Coastal Research, 28*(1A), 34–43. https://doi.org/10.2112/JCOASTRES-D-10-00172.1 5. Shen, L., Xu, H., & Guo, X. (2012). Satellite remote sensing of harmful algal blooms (HABs) and a potential synthesized framework. *Sensors, 12*(6), 7778–7803. https://doi.org/10.3390/s120607778 6. Turpie, K. R., Ackleson, S. G., Byrd, K. B., & Moisan, T. A. (2021). Science and applications of coastal remote sensing. *Frontiers in Marine Science, 8*, 641029. https://doi.org/10.3389/fmars.2021.641029
Web Resources:	1. https://www.isro.gov.in/Miscellaneous.html 2. https://www.earthdata.nasa.gov/

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Title of the Course	Marine Pharmaceuticals and Pharmacology
Course Code	MBT-6006
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026 - 27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	MBT-5002/ MBT-5003/ MBT-5206	
Course Objectives:	The aim of the course is • Explore marine biodiversity and its potential for drug discovery. • Study the pharmacological properties, mechanisms, and biotechnological applications of marine-derived compounds. • Understand regulatory, ethical, and commercial aspects of marine bioprospecting.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify and describe key classes of marine natural products and their pharmacological activities.	PSO1, PSO3, PSO4
	CO 2. Understand methods for isolation, purification, and characterization of marine bioactive compounds.	PSO1, PSO2, PSO3

	CO 3. Analyze case studies of marine-derived drugs in clinical and industrial use.		PSO4, PSO5, PSO6, PSO8	
	CO 4. Evaluate the regulatory, ethical, and sustainability challenges in marine bioprospecting.		PSO7, PSO4, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	***Marine Natural Products*** • Marine environment as a source of novel bioactive compounds. • Bioprospecting strategies and collection techniques. • Major classes of marine natural products: alkaloids, terpenoids, peptides, polyketides, macrolides, and steroids. • Marine symbionts in natural product synthesis. ***Extraction, Isolation, and Characterization Techniques*** • Sampling and preservation of specimens. • Extraction and purification methods: solvent extraction, supercritical fluid extraction, solid-phase extraction, Chromatography. • Structure elucidation: UV, IR spectroscopy, NMR, MS. • Bioassay-guided fractionation and high-throughput screening ***Pharmacology of Marine-derived Compounds*** • Drug–receptor interactions, dose-response relationships, therapeutic index. • Pharmacodynamics of marine-derived compounds • Pharmacokinetics - absorption, distribution, metabolism, and excretion (ADME).	**15**	CO1, CO2, CO3	K1, K2, K3, K4
Module 2:	***Major Pharmacological classes and mechanisms of Action*** • Case studies of marine-derived drugs: antibacterial, antiviral, antifungal, anticancer, anti-inflammatory, and neuroprotective activities.	**15**	CO3, CO4	K3, K4, K5, K6

	• Mechanisms: DNA damage, apoptosis induction, Cell wall synthesis inhibition, membrane disruption, nucleic acid interference, enzyme inhibition, neurotransmitter receptor targeting, viral replication inhibition. ***Toxicology and Safety Assessment*** • Marine toxin diversity: neurotoxins, cytotoxins, hepatotoxins, cardiotoxins. • Dose-response relationships. • *In-vitro* and *in-vivo* toxicity testing models. ***Drug Development and regulatory perspectives*** • Preclinical and clinical evaluation of marine-derived compounds. • Marine drug delivery systems. • Challenges in formulation, stability, and scalability of marine-derived drugs. • Patenting of marine natural products. • Ethical and legal considerations in marine bioprospecting (UNCLOS, CBD, Nagoya Protocol). • Sustainability and conservation of marine resources, Marine biorefineries. • Future prospects: synthetic biology and combinatorial biosynthesis in marine pharmacology.			
Pedagogy:	Lectures/tutorials/assignments/models			
Texts:	1. Botana, L. M. (Ed.). (2014). *Seafood and freshwater toxins: Pharmacology, physiology, and detection* (3rd ed.). CRC Press. 2. Brunton, L. L., Hilal-Dandan, R., & Knollmann, B. C. (Eds.). (2023). *Goodman & Gilman's: The pharmacological basis of therapeutics* (14th ed.). McGraw-Hill Education. 3. Fattorusso, E., Gerwick, W. H., & Taglialatela-Scafati, O. (Eds.). (2012). *Handbook of marine natural products*. Springer. 4. Katzung, B. G., Vanderah, T. W., & Trevor, A. J. (2021). *Basic and clinical pharmacology* (15th ed.). McGraw-Hill Education. 5. Kim, S.-K. (Ed.). (2015). *Springer handbook of marine biotechnology*. Springer.			
References/ Readings:				

	6. Kiyota, H. (Ed.). (2021). *Marine natural products* (Vol. 58). Springer. 7. Rang, H. P., Dale, M. M., Ritter, J. M., Flower, R. J., & Henderson, G. (2016). *Rang & Dale's pharmacology* (8th ed.). Elsevier. 8. Senevirathne, M., & Kim, S.-K. (Eds.). (2023). *Marine biotechnology: Applications in food, drugs, and energy*. Springer.

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Title of the Course	Lab in Marine Pharmaceutical and Pharmacology
Course Code	MBT-6007
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2026 - 27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	MBT-5002/ MBT-5005, MBT-5202/ MBT-5206	
Course Objectives:	• Isolate and extract bioactive metabolites from marine microbial symbionts • Analyze the biological activity of marine-derived compounds including antimicrobial, antioxidant, and enzyme inhibitory effects. • Evaluate pharmacological properties and safety of compounds using cytotoxicity, hemocompatibility, and model organism assays. • Simulate pharmacodynamic behavior through dissolution studies, GI stability assays, and molecular docking.	
Course Outcomes:	CO 1. Apply laboratory techniques to extract bioactive metabolites from marine microbial symbionts.	PSO1, PSO3
	CO 2. Analyze the biological activities of marine-derived compounds, including antimicrobial, antioxidant, and enzyme inhibitory effects.	PSO1, PSO2, PSO3

	CO 3. Evaluate the pharmacological safety and cytotoxicity of marine bioactive compounds.		PSO3, PSO6	
	CO 4. Apply in vitro and in silico methods to simulate pharmacodynamic behavior, including dissolution studies, gastrointestinal stability assays, and molecular docking.		PSO4, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Extraction of bioactive fractions from marine microbial symbionts. 2. Determination of bacteriolytic activity by MIC (Minimum Inhibitory Concentration) assay. 3. Antioxidant activity by DPPH radical scavenging assay. 4. Enzyme Inhibition Assay (α-amylase). 5. Nitroblue tetrazolium (NBT) assay for superoxide scavenging. 6. Chromatographic separation of bioactive fractions by TLC. 7. Spectroscopic characterization by UV, IR.	**15**	CO1, CO2	K2, K3, K4
Module 2:	1. Simulated gastrointestinal stability assay (pH, enzyme and bile salt tolerance). 2. Hemolysis & hemocompatibility test. 3. MTT assay for cytotoxicity. 4. Dose-response curve and LD_{50} estimation (*Artemia salina*). 5. Model drug dissolution study (Ascorbic acid). 6. QSAR, ADMET & Predictive Toxicology	**15**	CO3, CO4	K4, K5, K6
Pedagogy:	Hands-on experimentation in the laboratory/ Demonstration/ Models.			
Texts:	1. Blunt, J. W., & Munro, M. H. G. (2017). *Marine natural products: Practical approaches to isolation, structure elucidation, and bioactivity evaluation*. Springer. 2. Brown, T. A. (2016). *Gene cloning and DNA analysis: An introduction* (8th ed.). Wiley-Blackwell. 3. Chaurasia, H., & Pathak, A. (Eds.). (2021). *Experimental pharmacology for pharmacy and allied health sciences: Laboratory manual*. Springer.			
References/ Readings:				

	4. Fattorusso, E., Gerwick, W. H., & Taglialatela-Scafati, O. (Eds.). (2012). *Handbook of marine natural products*. Springer. 5. Harborne, J. B. (1998). *Phytochemical methods: A guide to modern techniques of plant analysis* (3rd ed.). Chapman & Hall. 6. Kulkarni, S. K. (2019). *Handbook of experimental pharmacology* (5th ed.). Vallabh Prakashan. 7. McLaughlin, J. L., Rogers, L. L., & Anderson, J. E. (1998). The brine shrimp lethality bioassay. In K. Hostettmann (Ed.), *Methods in plant biochemistry: Assays for bioactivity* (Vol. 6, pp. 1–37). Academic Press. 8. Whitesides, G. M., & Deutch, J. M. (Eds.). (2020). *Principles of drug discovery and development*. Springer. 9. Willmann, S., & Lippert, J. (Eds.). (2019). *Pharmacokinetic and pharmacodynamic data analysis: Concepts and applications*. Springer.

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Title of the Course	Research Methodology
Course Code	MBT-6008
Number of credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	The course aims to equip students with the conceptual and practical foundations of scientific research. It provides insights into identifying and formulating research problems, developing hypotheses, and designing effective experimental frameworks. Students will gain competence in applying statistical and analytical tools for data collection, interpretation, and validation. Emphasis is placed on scientific writing, manuscript preparation, and ethical practices in research, ensuring academic integrity and responsible conduct. The course aims to develop the critical, analytical, and creative thinking skills necessary for conducting independent research and communicating scientific findings in professional formats.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Define and remember fundamental concepts of research methodology, scientific method, and research ethics.	PSO1, PSO6

	CO 2. Explain research problem identification, hypothesis formulation, and the principles of good research design.		PSO1, PSO8	
	CO 3. Apply appropriate sampling methods, measurement tools, and data collection techniques to research studies.		PSO2, PSO3	
	CO 4. Analyze and interpret quantitative and qualitative research data using suitable statistical and computational tools.		PSO3, PSO7	
	CO 5. Evaluate the validity, reliability, and ethical integrity of scientific studies, avoiding plagiarism and research misconduct.		PSO5, PSO6	
	CO 6. Design and construct research proposals, manuscripts, and reports adhering to scientific and ethical standards.		PSO6, PSO7	
Content		**No. of Hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction to Research**: Meaning, Objectives, Motivation in Research. Concept of theory, empiricism, deductive, and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition. Research Process. • Good Laboratory Practices, Ethics in research • Research problem: Selecting and analyzing the research problem – problem statement formulation – formulation of hypothesis. Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance. • Research Design: Concept and Importance in Research – Components and Features of a good research design; Types of research design: concept, and uses of Exploratory, Descriptive, and Experimental Design: Concept of Independent & Dependent variables. • Defining the Aims and Objectives, Work Plan – Time-bound Frame.	**15**	CO1, CO2	K1, K2, K3
Module 2:	**Measurement, Data Collection, and Sampling Methods**.	**15**	CO3, CO4	K1, K2, K3, K4

	• Variables in Research – Measurement and scaling – Different scales – Construction of instrument – Validity and Reliability of instrument. • Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non-Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. • Determining the size of the sample-Practical considerations in sampling and sample size. • Data collection, Analysis, and Interpretation: Types of data: Primary and secondary data, Qualitative vs Quantitative data analyses – Univariate(frequency tables, bar charts, pie charts, percentages), Bivariate Cross tabulations.			
Module 3:	**Types of Scientific Writing and Reference Management** • Importance of communicating research; Research manuscript writing: reports, short communication, manuscript/original articles, review articles, thesis writing, editorials, books, book chapters. • Fundamentals of scientific paper: Drafting titles and framing abstracts, Authorship, Keywords, Introduction, Materials and Methods, Results and Discussion, Conclusion, Acknowledgement, Conflicts of Interest, Scientific Objectivity, and Bibliography. • Research proposal writing: Components of research proposal (funding-based and non-funding/PhD-based). • Selection of journals for publication: Tools for suggesting journals for publishing research, Open access and predatory journals, and cloned journals. • Publication/Research metrics - Impact factor, citation count, cite score, h-Index, g-Index. • Research evaluation: Peer review, Viva Voce. • Reference Styles and Formatting: Overview of different reference styles (APA, MLA, Chicago); Formatting in-text citations and reference lists; Creating bibliographies and webliographies.	**15**	CO5	K2, K3, K4, K5, K6

	• Reference Management Systems: Introduction to reference management software (EndNote, Zotero, Mendeley); Building and organizing a reference library; Importing references from databases.			
Module 4:	**Ethical aspects in academic writing** • Ethical issues in research: Code of Ethics in Research • Human and Animal Ethics • Scientific conduct and misconduct; Authorship issues • Plagiarism: Definition and types of plagiarism; Consequences of plagiarism in academia; Strategies to avoid plagiarism; Strategies to prevent scientific misconduct, Falsification, fabrication, misinterpretation of data. Salami, imalas and duplicate publication. • The investigation and punishment of scientific misconduct. • Introduction to plagiarism detection software (Turnitin, Grammarly, Dilbrit); Interpreting similarity reports; • Best practices for maintaining academic integrity. Government guidelines/Official Gazette (UGC Regulations 2018).	**15**	CO5, CO6	K1, K2, K3
Pedagogy	Lecture, Tutorial, Assignments, Presentations, Discussions			
Texts/	1. Kothari, C. R. (2008). *Research methodology: Methods and techniques* (2nd rev. ed.). New Age International. 2. Kumar, R. (2018). *Research methodology: A step-by-step guide for beginners*. SAGE Publications.			
References/ Readings	1. Cooray, P. G. (1992). *Guide to scientific and technical writing*. P. G. Cooray. 2. Marczyk, G. R., DeMatteo, D., & Festinger, D. (2010). *Essentials of research design and methodology*. Wiley. 3. Olsen, B. R., Benestad, H. B., & Laake, P. (Eds.). (2007). *Methodology in the medical and biological sciences*. Academic Press. 4. Shamoo, A. E., & Resnik, D. B. (2003). *Responsible conduct of research*. Oxford University Press. 5. University Grants Commission. (2018). *University Grants Commission (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations, 2018* (Gazette of India No. F.1-18/2010 (CPP-II)). Government of India.			

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Discipline Specific Vocational Elective (DSVE) Courses

Title of the Course	Seafood Processing Technology
Course Code	MBT-6401
Number of credits	4 (2T+2P)
Theory/Practical	Theory + Practical
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	Value Added course
Course for advanced learners	No

Pre-requisites for the Course:	No	
Course Objectives:	This course provides a comprehensive understanding of seafood science, processing technologies, and quality assurance systems. It emphasizes the biochemical, microbiological, and technological principles underlying seafood preservation and introduces recent advances in value-added products and product development. Students will gain insight into industrial practices, national and international safety standards, and the role of biotechnology in the seafood sector.	
Course Outcomes:		Mapped to PSO
	CO 1. Explain the biochemical composition, nutritional value, and spoilage mechanisms of fish and shellfish.	PSO1, PSO2

	CO 2. Describe the principles and methods of seafood processing and preservation technologies.			PSO4, PSO7
	CO 3. Apply quality assurance systems such as HACCP and GMP in seafood production.			PSO4, PSO6
	CO 4. Employ molecular and rapid detection methods for microbial quality evaluation.			PSO1, PSO3, PSO5
	CO 5. Identify and explore opportunities for value addition and by-product utilization in the seafood industry.			PSO4, PSO7, PSO8
	CO 6. Analyze the biochemical composition, microbial quality, and preservation efficiency of seafood and develop safe, high-quality value-added marine products			PSO1, PSO2, PSO4
Content		**No. of Hours**	**Mapped to CO**	**Cognitive Level**
Module 1	**Introduction to the Seafood Industry** • Overview of the Indian and Global seafood industry; Nutritional value and biochemical composition of fish and shellfish; • Post-mortem changes occurring in fish muscle: • Chemical, microbial, and enzymatic action during fish spoilage. • Stages of fish spoilage: Rigor mortis, Autolysis, microbial changes, Belly burst, Rancidity. • Causative agents for fish spoilage; Organoleptic tests for detection of spoilage	**15**	CO1, CO2	K1, K2, K3
	Seafood Processing and Preservation Technologies. • Principles of preservative methods – Curing (Drying, Salting, Smoking), Chilling, Freezing, Marinating and Canning. • Principles of freeze drying - Accelerated freeze drying and packing of freeze-dried products. • Packaging methods: Handling fresh fish, frozen packs; Modified atmosphere packaging, Vacuum packaging, and Active packaging. • Modern methods of preservation by irradiation.		CO2	K1, K2, K3

Module II	**Quality Assurance and Safety** • Seafood microbiology. Intrinsic and extrinsic parameters that affect microbial growth. • Food-borne pathogens: bacterial and fungal infections and intoxications; • Quality Assurance – Concepts of Hazard Analysis Critical Control Point (HACCP) in seafood safety; Good Manufacturing Practice (GMPs), Standard • Operating Procedure (SOPs). Determining the quality assurance of seafood. • National and International standards – ISO 9000: 2000 Series of Quality Assurance System, Codex Alimentarius.	**15**	CO3, CO4	K2, K3, K4, K5
	Novel Product Development • Fishery by-products: Cannery waste, fish feeds, silage, fish gelatin, fish glue, chitin and chitosan, pearl essence, fertilizers, etc. • Status of value addition to fish and fish products in the Indian seafood sector. Advantages of value addition. • Emerging technologies in seafood processing.		CO5	K2, K5, K6
Module III	**Biochemical and microbiological evaluation** • Determination of Proximate Composition of Fish (Moisture, Ash, Protein, Lipid) • Determination of pH, TVBN, and Peroxide Value • Thiobarbituric Acid Reactive Substances (TBARS) Assay • Detection of adulteration/ preservatives in sea food. • Microbial analysis of packaged/ processed seafood.	**30**	CO6	K3, K4, K5
Module IV	**Preservation & Processing Techniques and value-added products** • Preparation and Quality Evaluation of Salted and Dried Fish • Freezing Curve Study and Effect of Freezing Rate on Texture • Shelf-Life Evaluation of vacuum pack vs non-packed seafood under Chilled Storage.	**30**	CO6	K3, K4, K5, K6

	• Evaluation of canned Seafood products • Protease activity assay & its role in spoilage/processing • Collagen extraction from fish skin and gel strength measurement • Value-added product development: develop ready-to-eat fish products; assess sensory and microbial quality • Extraction of fish oil and evaluation of quality			
Pedagogy	Lecture, Tutorial, Assignments, Presentations, Hands-on experiments in the laboratory			
References/ Readings	1. Abeyrathne, E. D. N. S., Nam, K., & Ahn, D. U. (2021). Analytical methods for lipid oxidation and antioxidant capacity in food systems. *Antioxidants, 10*(10), 1587. https://doi.org/10.3390/antiox10101587 2. Alasalvar, C., Miyashita, K., & Shahidi, F. (2011). *Handbook of seafood quality, safety and health applications*. Wiley. 3. Borda, D., Nicolau, A. I., & Raspor, P. (2017). *Trends in fish processing technologies*. CRC Press. 4. Da Silva, N., Taniwaki, M. H., Junqueira, V. C., Silveira, N., Okazaki, M. M., & Gomes, R. A. R. (2018). *Microbiological examination methods of food and water: A laboratory manual*. CRC Press. 5. Food Safety and Standards Authority of India. (2016). *Manual of methods of analysis of foods: Fish and fish products*. FSSAI, Government of India. 6. Gaikwad, S., & Kim, M. J. (2024). Fish by-product collagen extraction using different methods and their application. *Marine Drugs, 22*(2), 60. https://doi.org/10.3390/md22020060 7. Hall, G. M. (2011). *Fish processing: Sustainability and new opportunities*. Wiley. 8. Hall, G. M. (2012). *Fish processing technology* (2nd ed.). Springer. 9. Jafari, H., Lista, A., Siekapen, M. M., Ghaffari-Bohlouli, P., Nie, L., Alimoradi, H., & Shavandi, A. (2020). Fish collagen: Extraction, characterization, and applications for biomaterials engineering. *Polymers, 12*(10), 2230. https://doi.org/10.3390/polym12102230 10. Martin, R. E., Flick, G. J., Hebard, C. E., & Ward, D. R. (2012). *The seafood industry: Species, products, processing, and safety*. Wiley. 11. Sen, D. P. (2005). *Advances in fish processing technology*. Allied Publishers.			

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Title of the Course	Algal Biotechnology and Bioeconomy
Course Code	MBT-6402
Number of Credits	4
Theory/Practical	Theory + Practical
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	• To understand the physiological, biochemical, and ecological roles of microalgae and macroalgae in global carbon cycling, productivity, and the blue bioeconomy. • To develop knowledge of microalgal cultivation systems, strain selection, and downstream processing for biofuel and high-value biomolecule production. • To examine the biochemical composition, cultivation, and molecular biology of seaweeds for biotechnological and industrial applications. • To evaluate the sustainability, environmental impact, and biorefinery approaches integrating algal biotechnology within the blue economy framework. • To develop practical skills in culturing, maintaining, isolating, and identifying microalgal and macroalgal species using standard laboratory and taxonomic techniques. • To train students in biomass estimation, growth analysis, and extraction of pigments and bioactive compounds for biotechnological applications.

Course Outcomes:	At the end of the course students will be able to		**Mapped to PSO**	
	CO 1. Explain the physiological, biochemical, and ecological roles of microalgae and macroalgae in global carbon cycling and productivity.		PSO1, PSO3, PSO6, PSO7	
	CO 2. Demonstrate understanding of algal cultivation systems, strain selection, and downstream processing for biofuel and biomolecule production.		PSO1, PSO2, PSO3, PSO6	
	CO 3. Analyze the biochemical composition and molecular biology of seaweeds for industrial and biotechnological applications.		PSO1, PSO2, PSO3, PSO4, PSO5, PSO6	
	CO 4. Evaluate sustainability and biorefinery approaches integrating algal biotechnology within the blue economy framework.		PSO3, PSO4, PSO6, PSO7	
	CO 5. Perform isolation, culturing, maintenance, and identification of microalgal and macroalgal species using standard laboratory techniques.		PSO1, PSO2, PSO3, PSO5, PSO6, PSO8	
	CO 6. Estimate algal biomass and extract pigments and bioactive compounds for biotechnological evaluation.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Microalgal Biotechnology and Bioeconomy** **Introduction & Scope** • Importance of microalgae in global primary productivity and carbon cycling • CO_2 sequestration potential • Overview of role in the bioeconomy: feed, food, fuel, pharmaceuticals, pigments, aquaculture applications **Diversity, Physiology & Strain Selection** • Major industrially relevant groups: o Chlorophyta (e.g., *Chlorella*, *Scenedesmus*): lipid accumulation, biofuels, nutraceuticals o Bacillariophyta (diatoms, e.g., *Phaeodactylum*, *Navicula*): silica frustules,	**15**	CO1, CO2, CO3, CO4	K2, K4, K6

	PUFA production ○ Cyanobacteria (e.g., *Arthrospira/Spirulina*): protein-rich biomass, pigments (phycocyanin) • Strain selection criteria: productivity, product profile, stress tolerance, GRAS status **Cultivation Systems & Scale-up** • Growth requirements: light, nutrients, CO_2, and temperature • Open systems (raceway ponds): design, advantages, and limitations • Closed photobioreactors (PBRs): basic types and operational considerations • Brief overview of hybrid systems and scale-up challenges **Harvesting & Downstream Processing** • Overview of harvesting methods: flocculation, sedimentation, centrifugation, membrane filtration. • Cell disruption techniques: mechanical and non-mechanical methods • Extraction approaches: solvent extraction, supercritical CO_2 • Purification strategies: chromatography, crystallisation **Products and Applications** • **Biofuels**: Triacylglycerol induction via nutrient stress (N starvation), Biodiesel production pipeline and limitations in commercial feasibility • **High-value metabolites**: Pigments , phycobiliproteins, Polyunsaturated fatty acids, Antioxidants • **Proteins & Polysaccharides**: Single-cell protein; Exopolysaccharides with immunomodulatory activity • **Bioactive molecules**: antimicrobial, antiviral, anticancer compounds • **Biorefinery approach**: Concept of cascade utilization: fuels + pigments + proteins + co-products, Example flowsheets integrating multiple product streams **Applications in Phytoremediation** • Nutrient removal (nitrogen, phosphorus)			

	• Heavy metal sequestration • Integration with aquaculture wastewater treatment			
Module 2:	**Macroalgal Biotechnology and Bioeconomy** **Introduction to Seaweed Biology** • Classification and taxonomy of seaweeds (Rhodophyta, Phaeophyceae, Chlorophyta) • Morphology and anatomy of macroalgae • Life cycles and reproduction **Seaweed Cultivation and Harvesting** • Methods of seaweed farming (offshore, onshore) • Environmental factors affecting growth • Seed production and nursery techniques • Seaweed-Microbe Interactions: Role of microbial communities in seaweed health, growth, nutrient cycling, and disease resistance • Harvesting and post-harvest handling **Seaweed Biochemistry and Molecular Biology** • Primary and secondary metabolites in seaweeds • Biochemical composition: polysaccharides (agar, carrageenan, alginate), proteins, lipids, pigments • Molecular tools in seaweed biotechnology (DNA barcoding, genetic markers) **Biotechnological Applications of Seaweeds** • Seaweed Biorefinery • Production of food, feed, and bioactive compounds • Industrial applications: pharmaceuticals, nutraceuticals, cosmetics, Biofuel, and bioplastics from macroalgae • Seaweed in wastewater treatment and carbon sequestration **Genetic Engineering and Molecular Breeding**	**15**	CO1, CO2, CO3, CO4	K2, K5, K6

	• Genetic modification approaches in seaweeds • Breeding strategies for enhanced traits • Challenges and ethical considerations **Sustainable Seaweed Industry** • Blue Bioeconomy and role of seaweeds • Market trends and economic potential • Environmental impact and sustainability of seaweed farming • Policy and regulatory aspects			
Module 3:	**Microalgal Technology** • Preparation of Culture Media for Marine and Freshwater Phytoplankton. • Isolation and identification of microalgae using standard identification keys. • Cell enumeration and growth curve analysis • Methods for harvesting Microalgal biomass • Pigment Extraction and Characterization • Extraction of primary and secondary metabolites from microalgae	**30**	CO5, CO6	K2, K3, K4
Module 4:	**Macroalgal Biotechnology and Bioeconomy** • Seaweed collection from coastal habitat • Seaweed preservation techniques (herbarium preparation) • Morphological identification using dissecting and compound microscopes • Media preparation, cultivation of Ulva culture • Seaweed biomass estimation: Calculation of productivity & biomass yield • Extraction of Bioactive Compound from seaweed.	**30**	CO5, CO6	K2, K3, K4
Pedagogy:	Lectures/tutorials/assignments/Hands-on experiments in the laboratory/Field training/Demonstration/online/self-study			
Texts, References/ Readings:	1. Andersen, R. A., & Kawachi, M. (2005). Microalgae isolation techniques. In R. A. Andersen (Ed.), *Algal culturing techniques* (pp. 83–92). Elsevier. 2. Cameselle, C., Maceiras, R., & Rodríguez, M. (2025). Optimization of ultrasound-assisted extraction of bioactive			

compounds and biopolymers from *Ulva* spp. *Journal of Applied Phycology*. https://doi.org/10.1007/s10811-025-03492-2

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4. Ganesan, P., Kumar, C. S., & Bhaskar, N. (2019). Seaweed extracts as a modern bio-stimulant: An emerging trend in agriculture and forestry. *Journal of Applied Phycology*, *31*(1), 123–136. https://doi.org/10.1007/s10811-018-1602-x
5. Gopinathan, C. P., Rajagopalan, M., Kaladharan, P., & Prema, D. (2007). *Training manual on phytoplankton identification/taxonomy*. [Publisher not specified].
6. Holdt, S. L., & Kraan, S. (2011). Bioactive compounds in seaweed: Functional food applications and legislation. *Journal of Applied Phycology*, *23*(3), 543–597. https://doi.org/10.1007/s10811-010-9632-5
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8. Kim, S.-K., & Bhatnagar, I. (Eds.). (2011). *Seaweed biology: Novel insights into ecophysiology, ecology and utilization*. CRC Press.
9. Moncheva, S., Parr, B., Sarayi, D., & Hareket, I. I. (2010). *Manual for phytoplankton sampling and analysis in the Black Sea*. UP-GRADE Black Sea Scene Project (FP7 226592).
10. Pappou, S., Tziveleka, L.-A., Ioannou, E., & Roussis, V. (2022). Extraction of bioactive compounds from the green seaweed *Ulva lactuca*: Optimization and evaluation of antioxidant activity. *Applied Sciences*, *12*(4), 2117. https://doi.org/10.3390/app12042117
11. Reynolds, C. S. (2006). *The ecology of phytoplankton*. Cambridge University Press.
12. Robles-Carnero, M., García-Balboa, C., Morales-Amador, A., Sánchez-Rodríguez, I., & López-Figueroa, F. (2024). Biomass productivity and photosynthetic activity in *Ulva rigida* (Chlorophyta) cultured under different conditions of light and nutrients. *Plants*, *13*(12), 1612. https://doi.org/10.3390/plants13121612
13. Royal Botanic Garden Edinburgh. (2017). *Preparation and care of herbarium specimens* (Rev. ed., November 6, 2017). https://www.rbge.org.uk/media/4584/preparation-care-and-art-of-herbarium-specimens-revised-6-nov-2017.pdf
14. Singh, R. P., & Reddy, C. R. K. (2014). Seaweed–microbial interactions: Key functions of seaweed-associated bacteria. *FEMS Microbiology Ecology*, *88*(2), 213–230. https://doi.org/10.1111/1574-6941.12228
15. Sluiman, H. (2009). [Review of the book *Phycology* by R. E. Lee]. *Edinburgh Journal of Botany*, *66*(3), 483–484.

	16. Smithsonian National Museum of Natural History. (n.d.). *Algae preservation techniques*. Smithsonian Institution. https://naturalhistory.si.edu/research/botany/research/algae/algae-preservation-techniques 17. Tomas, C. R. (Ed.). (1997). *Identifying marine phytoplankton*. Elsevier. 18. Venkatesan, J., Anil, S., & Kim, S.-K. (Eds.). (2017). *Seaweed polysaccharides: Isolation, biological and biomedical applications*. Elsevier.
Web Resources:	1. https://roscoff-culture-collection.org/ 2. https://seaweedhub.extension.uconn.edu/

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Title of the Course	Aquaculture Technology
Course Code	MBT-6403
Number of Credits	4
Theory/Practical	Theory + Practical
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	MBT-5001/ MBT-5003
Course Objectives:	The aim of the course is to: • Introduce the principles and practices of aquaculture and its relevance in Biotechnology. • Provide comprehensive knowledge of aquatic organism biology, nutrition, culture systems, feed evaluation and water quality management. • Familiarize students with modern aquaculture technologies such as biofloc, recirculating aquaculture systems (RAS), and ornamental fish culture. • Promote sustainable aquaculture practices integrating ecological, biotechnological, and economic perspectives. • Provide hands-on training and develop technical skills in essential aquaculture practices, including feed formulation, live feed culture, larval rearing, and induced breeding. • Train students in water quality assessment, aquafeed analysis, and modern aquaculture technologies such as biofloc, RAS and pearl culture.

Course Outcomes:	At the end of the course students will be able to:			**Mapped to PSO**
	CO 1. Explain the fundamental principles, scope, and practices of aquaculture.			PSO1, PSO4, PSO7
	CO 2. To understand the biology, nutrition, and environmental requirements of aquatic organisms.			PSO1, PSO2, PSO4
	CO 3. To explore modern aquaculture systems such as biofloc, RAS, and ornamental fish culture.			PSO2, PSO4, PSO7, PSO8
	CO 4. Evaluate sustainable aquaculture strategies integrating ecological, biotechnological, and economic perspectives.			PSO4, PSO6, PSO7
	CO 5. Formulate and evaluate nutritionally balanced fish feeds, and demonstrate proficiency in larval rearing, live feed culture, and nursery management.			PSO1, PSO2, PSO4, PSO8
	CO 6. Assess fish health and aquaculture productivity, and apply advanced techniques in induced breeding, ornamental fish culture, RAS, and pearl farming.			PSO1, PSO4, PSO5, PSO8
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	***Introduction to Aquaculture systems*** • Classification: Extensive, semi-intensive, intensive, integrated, and ornamental aquaculture. • Selection of culture species: finfish, shellfish, molluscs, and aquatic plants. • Aquaculture infrastructure: ponds, cages, raceways, tanks, and RAS. • Water quality parameters: temperature, DO, pH, ammonia, nitrate, and salinity, environmental sustainability. ***Nutrition and Feed Technology:*** • Nutritional requirements of fish and shrimp: proteins, lipids, carbohydrates, vitamins, minerals, feed additives. • Artificial Feed formulation: Pearson's square method and feed palletisation. ***Breeding, Hatchery, and Larval Rearing:***	15	CO1, CO2	K1, K2, K3, K4

	• Induced breeding: hormonal induction, fertilization, incubation, and larval care. • Live feed culture: Artemia, rotifers, and microalgae. • Biomass calculation based on feed intake (SGR, FCR, FE, DFR etc.) • Post-harvest technology: Fundamental aspects of freezing			
Module 2:	***Principles of Fish Breeding:*** • Primary and secondary sex characters. • Neuroendocrine system & its role in reproduction. • Pheromones in reproductive behaviour. • Hypophysation and Cryopreservation technique • Hormone induced ovulation. • Synthetic hormones for induced breeding ***Biotechnological applications in aquaculture:*** • Artificial Hybridization: Heterosis. • Selective breeding, Transgenics and triploidy. • Vaccines and immunostimulants in fish health. ***Emerging trends in aquaculture*** • Pearl culture technology. • Aquaponics, biofloc, and recirculating aquaculture systems (RAS). • Genetically modified organisms in Bioremediation. • Artificial Intelligence in the Aquaculture industry. • Schemes for entrepreneurship and start-ups in aquaculture technology.	15	CO3, CO4	K3, K4, K5
Module 3:	• Formulation of artificial pellet feed using Pearson's square method. • Nutrient analysis of fish feed. • Fish handling and biomass assessment (DFR, FCR, SGR, yield).	30	CO5, CO6	K2, K3, K4

	• Propagation and maintenance of live feed organisms (brine shrimp/ microworms) for larval culture. • Examination of diseased fish (clinical, microbiological/ histopathology). • Assessment of probiotics for aquaculture (Acid and Bile Salt Tolerance, Enzyme activity, Antagonistic activity). • Estimation of ammonia in aquaculture pond water.			
Module 4:	• Demonstration of induced fish breeding techniques (injection, stripping, fertilization). • Ornamental fish culture and management. • Set-up of a small-scale Aquaponics model system. • Study of pearl culture techniques (seeding, nucleus implantation). • Fish/shrimp cell culture. • Field trip: Visit to a Biofloc / Recirculating aquaculture system (RAS) and a semi-intensive aquafarm.	30	CO5, CO6	K3, K4, K5
Pedagogy:	Lectures/ tutorials/ assignments/ models/ Hands-on experimentation in the laboratory / Demonstration/ Field training.			
Texts, References/ Readings:	1. Allan, G., & Burnell, G. (2013). *Advances in aquaculture hatchery technology*. Woodhead Publishing. https://doi.org/10.1533/9780857097460 2. Carranzo, I. V. (2012). [Review of *Standard methods for the examination of water and wastewater* by APHA, AWWA, & WEF]. *Anales de Hidrología Médica*, *5*(2), 185–186. https://doi.org/10.5209/rev_anhm.2012.v5.n2.40440 3. Caspers, H. (1985). [Review of *A manual of chemical and biological methods for seawater analysis* by T. R. Parsons, Y. Maita, & C. M. Lalli]. Pergamon Press. 4. Central Institute of Fisheries Education. (1993). *Training manual on culture of live food organisms for aqua hatcheries*. CIFE. 5. Felix, S. (2010). *Marine and aquaculture biotechnology*. Agrobios (India). 6. Fernandes, S. (2024). Artificial intelligence in the aquaculture industry: Current state, challenges and future directions. *Aquaculture*. Advance online publication. https://doi.org/10.1016/j.aquaculture.2024.742048			

	7. Food and Agriculture Organization of the United Nations. (2020). *The state of world fisheries and aquaculture 2020*. FAO. https://doi.org/10.4060/ca9229en 8. Jain. (2018). *Practical manual on fish nutrition and feed technology*. Scientific Publishers. 9. Kim, S.-K. (Ed.). (2015). *Springer handbook of marine biotechnology*. Springer. 10. Lakra, W. S., & Gopalakrishnan, A. (2021). Blue revolution in India: Status and future perspectives. *Indian Journal of Fisheries, 68*(1). https://doi.org/10.21077/ijf.2021.68.1.109283-19 11. Marine Products Export Development Authority. (1993). *Handbook on aqua farming: Live feed (microalgal culture)*. MPEDA. 12. Selvamani, B. R., & Mahadevan, R. K. (2008). *Aquaculture: Trends and issues*. Campus Books. 13. Stickney, R. R. (2022). *Aquaculture: An introductory text*. CABI.
Web Resources:	1. https://www.fao.org/fishery/en 2. https://enaca.org/

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SEMESTER IV

Generic Elective (Ge) Courses

Title of the Course	Blue economy
Course Code	MBT-6201
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course:	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil
Course Objectives:	• To understand the principles, scope, and significance of the Blue Economy in national and global contexts. • To familiarize students with key marine bioresources and their biotechnological applications in value addition and circular economy. • To comprehend policy, governance, and sustainability frameworks regulating marine biotechnological activities. • To encourage innovation and entrepreneurship through translational case studies and product/market design exercises

Course Outcomes:	At the end of the course, the students will be able to:		Mapped to PSO	
	CO 1. Explain the concept, components, and relevance of the Blue Economy in sustainable development.		PSO4, PSO6, PSO7	
	CO 2. Identify major marine bioresources and outline biotechnology-based value chains.		PSO1, PSO2, PSO4	
	CO 3. Assess policy, ethical, and environmental considerations in marine bioresource utilization.		PSO5, PSO6, PSO7	
	CO 4. Design a conceptual plan or policy brief linking marine biotechnology to industry or community benefit.		PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**<u>Foundations of the Blue Economy</u>** ***Concept and Scope*** • Definition and evolution of Blue Economy and Blue Bioeconomy. • Comparison with Green Economy and Circular Economy. • UN Sustainable Development Goals (SDG 14 and related goals). ***National and Global Perspectives*** • India's Blue Economy Policy framework, "Ocean Vision 2030," and relevant ministries (DBT, MoES, ICAR, MoEFCC). • Major national programmes: Deep Ocean Mission, O-SMART, Marine Biodiversity Programme, Seaweed Mission, Fisheries and Aquaculture Initiatives. • Global initiatives: UN Decade of Ocean Science, FAO and OECD frameworks. ***Governance, Ethics and Sustainability*** • Coastal regulation, marine spatial planning, biodiversity and ABS frameworks (CBD, Nagoya Protocol). • Environmental Impact Assessment (EIA), marine protected areas, and community participation.	**15**	CO1, CO3	K1, K2, K4

	• Blue financing, carbon credits, and sustainability metrics. ***Stakeholders and Value Chains*** • Academia-Industry- Community partnerships, coastal livelihood improvement models, and startup ecosystems.			
Module 2:	**<u>Marine Biotechnology and Blue Economy Applications</u>** ***Marine Bioresources and Biotechnological Applications*** • Microalgae, macroalgae, marine microbes, sponges, cnidarians, crustaceans, and fishery by-products. • Value-added sectors: nutraceuticals, pharmaceuticals, cosmeceuticals, biomaterials, biofertilizers, and marine-derived enzymes. ***Translational Pathways and Entrepreneurship*** • Blue biotech startups, incubators, and technology transfer mechanisms. • Regulatory approval and commercialization steps (FSSAI, CDSCO, GMP). • Business model canvas for marine biotechnology products. ***Sustainability and Socio-Economic Dimensions*** • Ecosystem-based management, community-led aquaculture, and gender-inclusive blue enterprises. • Case studies: Seaweed value chain in India, bioplastics from marine waste, sustainable fisheries, coastal bio-entrepreneurship.	**15**	CO2, CO3, CO4	K3, K6
Pedagogy:	Lectures/tutorials/assignments/seminars/class discussions/ICT			
Texts:	1. Kim, S.-K. (2019). *Essentials of marine biotechnology*. Springer. 2. Sanjeewa, K. K. A. (2024). *Exploring the blue bioeconomy: Marine bioresources and sustainable applications* (1st ed.). CRC Press. 3. Zacharias, M. (2014). *Marine policy: An introduction to governance and international law of the oceans* (1st ed.). Routledge.			
References/ Readings:	1. Blythe, J. L., Armitage, D., Bennett, N. J., Silver, J. J., & Song, A. M. (2021). The politics of ocean governance transformations. *Frontiers in Marine Science, 8*, 634718. https://doi.org/10.3389/fmars.2021.634718			

	2. Daniotti, S., & Re, I. (2021). Marine biotechnology: Challenges and development market trends for the enhancement of biotic resources in industrial pharmaceutical and food applications: A statistical analysis of scientific literature and business models. *Marine Drugs*, *19*(2), 61. https://doi.org/10.3390/md19020061 3. Elston, J., Pinto, H., & Nogueira, C. (2024). Tides of change for a sustainable blue economy: A systematic literature review of innovation in maritime activities. *Sustainability*, *16*(24), 11141. https://doi.org/10.3390/su162411141 4. Persson, B., Fernqvist, N., Meijer, M. W., Bengtsson, D., & Mattisson, D. (2025). Mapping the governance landscape of the blue bioeconomy: A systems approach to understanding innovation barriers and enablers. *Ocean & Coastal Management*, *270*, 107899. https://doi.org/10.1016/j.ocecoaman.2024.107899 5. Ragozzino, C., Casella, V., Coppola, A., Scarpato, S., Buonocore, C., Consiglio, A., … Coppola, D. (2025). Last decade insights in exploiting marine microorganisms as sources of new bioactive natural products. *Marine Drugs*, *23*(3), 116. https://doi.org/10.3390/md23030116 6. Shih, Y. C., Chen, W. C., Chen, T. A. P., & Chang, C. W. (2023). The development of ocean governance for marine environment protection: Current legal system in Taiwan. *Frontiers in Marine Science*, *10*, 1106813. https://doi.org/10.3389/fmars.2023.1106813
Web Resources:	1. https://www.moes.gov.in/sites/default/files/2025-05/White-Paper_Blue_Economy.pdf 2. https://www.indiascienceandtechnology.gov.in/listingpage/ocean-initiatives 3. https://www.moes.gov.in/schemes/dom 4. impriindia.com/insights/o-smart-indias-vision-for-ocean-services

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Title of the Course	Trends in Sustainable Waste Resource Management
Course Code	MBT-6202
Number of Credits	04
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	Yes

Pre-requisites for the Course:	GBT-5203, GBT-5204, MBT-5203, MBT-5024
Course Objectives:	The course is aimed to: • Impart knowledge of global and local water and waste challenges, with a focus on biotechnological solutions for wastewater and solid waste treatment. • Explore biological and microbial approaches for wastewater treatment, nutrient recovery, and sustainable reuse of treated water. • Introduce biotechnological innovations in organic waste treatment, composting, and integrated solid waste biorefineries for energy and material recovery. • Understand advanced bioprocesses and future technologies, including microbial fuel cells, bioleaching, biohydrogen production, and circular bioeconomy principles.

Course Outcomes:			**Mapped to PSO**	
	CO 1. Analyze global and regional water and waste issues and evaluate the role of biotechnology in addressing these challenges.		PSO1, PSO3, PSO7	
	CO 2. Apply microbial and enzymatic processes for wastewater treatment, nutrient recovery, and non-potable water reuse.		PSO1, PSO2, PSO6	
	CO 3. Assess and compare biotechnological methods for solid waste treatment, including composting, anaerobic digestion, and biorefineries.		PSO3, PSO4, PSO6	
	CO 4. Evaluate advanced and emerging biotechnologies (e.g., microbial electrochemical systems, bioleaching, biohydrogen production) for energy and material recovery from waste.		PSO4, PSO5, PSO6, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Biotechnological Approaches to Wastewater Treatment and Global Water Challenges** • Global and India-specific water demand and wastewater challenges • The role of biotechnological innovations in addressing the water crisis • Water consumption vs. supply: How biological wastewater treatment contributes to water sustainability • Microbial and biotechnological solutions to reduce environmental and health impacts of untreated wastewater • Biotreatment challenges across major sectors (domestic, industrial, agricultural) • Impacts of complex wastewater composition on microbial treatment efficacy and bio-process design • Decentralized biotreatment systems: Advantages of bio-based systems in flexible, site-specific treatment • Biotech perspective on decentralized vs. centralized/on-site systems: Microbial community management, scalability, and adaptability.	**15**	CO1, CO2	K2, K3, K4, K5

Module 2:	**Resource Recovery from Wastewater through Biotechnological Innovations** • Biological reuse systems: Microbial treatment for non-potable water reuse (e.g., irrigation, cooling, flushing) • Microbial and enzymatic recovery of resources: Nitrogen, phosphorus, metals, and organic matter • Energy recovery: Biogas production, microbial fuel cells (MFCs), and microbial electrochemical technologies (MECs) • Advanced biotech processes: Anaerobic digestion, membrane bioreactors, and bio-electrochemical systems • Integration of biotechnology into circular water economy: Using engineered microbes for enhanced recovery and treatment • Future trends: Genetically modified microbes, microbiome engineering. • Omics-based monitoring in treatment and recovery systems.	**15**	CO2, CO4	K3, K4, K5, K6
Module 3:	**Organic Waste Treatment and Resource Recovery** • Overview of organic waste treatment technologies with emphasis on recovery • Sustainable development and environmentally friendly biotech practices • Recycling and composting techniques: traditional and novel methods (e.g., terra preta, vermicomposting, black soldier fly larvae) • Anaerobic digestion for energy and nutrient recovery • Nutrient recycling technologies for soil enhancement • Biotechnological innovations in composting and nutrient cycling • Waste utilization in agriculture: recycling crop residues, agri-byproducts into nutrient-rich manure and biomethane • Bioconversion of solid waste into cattle feed and soil conditioners	**15**	CO3	K2, K3, K4, K5,K6
Module 4:	**Advanced Biotechnologies for Energy and Bioresource Recovery from Solid Waste**	**15**	CO3, CO4	K3, K4, K5, K6

	• Integrated solid waste biorefineries: production of biofuels, biochemicals, and bioenergy • Waste-to-Energy technologies: incineration, thermochemical conversion, microbial electrolysis cells • Clean biological hydrogen production and biofuel generation • Biomass valorization: wood waste, agricultural waste, MSW, sewage sludge as bioenergy sources • Bioleaching, biopolymer production, and carbon capture/sequestration • Technological innovations in biotech-based waste management • Environmental impacts and challenges: effects and mitigation of combustion by-products			
Pedagogy:	Lectures/tutorials/assignments/ online/self-study			
Texts, References/ Readings:	1. Kiran, E. U., Trzcinski, A. P., Ng, W. J., & Liu, Y. (2014). Bioconversion of food waste to energy: A review. *Fuel, 134*, 389–399. https://doi.org/10.1016/j.fuel.2014.05.074 2. Lens, P. N. L., & Pol, L. H. (Eds.). (2000). *Environmental technologies to treat sulfur pollution: Principles and engineering*. IWA Publishing. 3. Logan, B. E., & Rabaey, K. (2012). Conversion of wastes into bioelectricity and chemicals by using microbial electrochemical technologies. *Science, 337*(6095), 686–690. https://doi.org/10.1126/science.1217412 4. Mohan, S. V., Modestra, J. A., Amulya, K., Butti, S. K., & Velvizhi, G. (2016). A circular bioeconomy with biobased products from CO_2 sequestration. *Trends in Biotechnology, 34*(6), 506–519. https://doi.org/10.1016/j.tibtech.2016.02.012 5. Owamah, H. I., & Dahunsi, S. O. (2021). Biotechnological applications for the treatment and valorization of food waste: A review. *Bioresource Technology, 337*, 125597. https://doi.org/10.1016/j.biortech.2021.125597 6. Pandey, A., Negi, S., Soccol, C. R., & Larroche, C. (Eds.). (2022). *Biotechnology for sustainable environment*. Elsevier. 7. Rittmann, B. E., & McCarty, P. L. (2020). *Environmental biotechnology: Principles and applications* (2nd ed.). McGraw-Hill Education.			

	8. Singh, R. P., Ibrahim, M. H., & Esa, N. (2011). Composting of waste from municipal solid waste. *International Journal of Environmental Sciences, 1*(7), 1520–1530. 9. Tchobanoglous, G., Burton, F. L., Stensel, H. D., & Tsuchihashi, R. (2014). *Wastewater engineering: Treatment and resource recovery* (5th ed.). McGraw-Hill Education. 10. Verstraete, W., & Vlaeminck, S. E. (2011). ZeroWasteWater: Short-cycling of wastewater resources for sustainable cities of the future. *International Journal of Sustainable Development & World Ecology, 18*(3), 253–264. https://doi.org/10.1080/13504509.2011.570804
Web Resources:	1. https://www.unwater.org 2. https://cpcb.nic.in 3. https://www.iwa-network.org 4. https://www.epa.gov/water-research

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Title of the Course	Model Organisms for Genomic Research
Course Code	MBT-6203
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To introduce the concept, selection criteria, and historical significance of model organisms in advancing genomic research. • To provide comprehensive knowledge of prokaryotic, fungal, plant, invertebrate, vertebrate, and human model systems. • To train students to access and utilize specialized genomic databases and resources associated with diverse model organisms. • To highlight the applications of model organism research in diverse area, and biotechnology, while addressing ethical, legal, and societal considerations.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the conceptual foundations and historical development of model organisms, describing the criteria for their selection and significance in genomic research.	PSO 1, PSO 3, PSO 8

	CO 2. Compare and interpret the genetic, molecular, and physiological features of key prokaryotic and fungal models to understand conserved biological mechanisms.		PSO 1, PSO 3, PSO 8	
	CO 3. Analyze plant and agricultural model systems to elucidate the molecular basis of development, stress responses, and traits relevant to sustainability and food security.		PSO 1, PSO 4, PSO 7	
	CO 4. Evaluate the use of invertebrate and vertebrate models in developmental, genetic, and disease research, integrating data from dedicated genomic databases.		PSO 1, PSO 3, PSO 8	
	CO 5. Assess the contributions of human genomic studies—including variation, evolution, and disease genomics—to biomedical and translational research.		PSO 1, PSO 3, PSO 5	
	CO 6. Integrate genomic information across multiple model systems to draw comparative and evolutionary inferences, while critically appraising the ethical, legal, and social implications (ELSI) of genomic research.		PSO 3, PSO 6, PSO 7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to model organisms: Concept, criteria for selection, advantages, and limitations significance in genomics, historical milestones. **Prokaryotic models:** Escherichia coli (E. coli K-12): molecular genetics, recombinant DNA technology, metabolic pathways. Bacillus subtilis: differentiation, sporulation, gram-positive model. Prokaryotic genomic database (proGenomes, ProPan) **Yeast and fungal models:** Saccharomyces cerevisiae: eukaryotic gene regulation, cell cycle, proteomics. Schizosaccharomyces pombe: mitosis, epigenetics, genome stability. Neurospora crassa: circadian rhythms, fungal genetics, gene silencing. Databases resource for fungi (Fungidb, SGD).	**15**	CO 1 CO 2	K2, K4
Module 2:	**Plant and Agricultural Models**	**15**	CO 3	K2, K4

	Arabidopsis thaliana: development, stress genomics, epigenetics. Oryza sativa (Rice): crop genomics, food security, comparative genomics. Medicago truncatula nodulation, plant–microbe interactions, legume genomics. Brachypodium distachyon: grass genomics, bioenergy crops. Plant databases: TAIR, Rice Genome Annotation Project, Ensembl Plant, Legume Information System. Applications in sustainable agriculture, food security, and climate resilience.			
Module 3:	**Invertebrate models:** Caenorhabditis elegans (Nematode): cell lineage mapping, RNAi, developmental biology. Drosophila melanogaster (Fruit fly): genetics of development, signaling pathways, disease models. Databases resources for invertebrate (Ensemble metazoa, FlyBase, WormBase). **Vertebrate models:** Danio rerio (Zebrafish): embryogenesis, organ development, regeneration, live imaging. Mus musculus (Mouse): mammalian genomics, transgenics, disease models. Databases resources for vertebrate (Ensemble Vertebrate, ZFIN, MGD and RGD).	**15**	CO 4	K4, K5
Module 4:	Humans as a system: opportunities and challenges. The Human Genome Project: milestones, outcomes, and legacy. Human genetic variation: SNPs, structural variants, copy number variation. Evolutionary genomics and human ancestry. Human genomics in health and disease: cancer, neurological disorders, rare diseases. Ethical, legal, and social implications (ELSI) of human genomic research. Human genomic databases and resources (NCBI, Ensemble, ENCODE, HSCDG, , Human Cell Atlas).	**15**	CO 5 CO6	K4, K5, K6
Pedagogy:	Lectures/ tutorials/assignments/models/group discussion/ICT			

Texts:	1. Davis, R. H. (2000). *Neurospora: Contributions of a model organism*. Oxford University Press.
References/ Readings:	2. Davis, R. H. (2003). *The microbial models of molecular biology: From genes to genomes*. Oxford University Press. 3. Green, S. (2024). *Animal models of human disease*. Cambridge University Press. 4. Grotewold, E., Chappell, J., & Kellogg, E. A. (2015). *Plant genes, genomes and genetics*. Wiley. 5. Kavanagh, K. (2017). *Fungi: Biology and applications*. Wiley. 6. McCluskey, K., & Robert, L. J. (2021). *The biological resources of model organisms*. Taylor & Francis Group. 7. Striedter, G. F. (2022). *Model systems in biology: History, philosophy, and practical concerns*. MIT Press.
Web Resources:	1. https://progenomes.embl.de 2. https://fungidb.org/fungidb/ 3. https://www.yeastgenome.org 4. https://www.arabidopsis.org 5. http://rice.plantbiology.msu.edu 6. https://flybase.org 7. https://wormbase.org 8. https://zfin.org 9. http://www.informatics.jax.org 10. https://rgd.mcw.edu 11. https://www.ncbi.nlm.nih.gov/ 12. https://www.ensembl.org 13. https://www.encodeproject.org 14. https://www.humancellatlas.org

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Title of the Course	Modern Agricultural Techniques and Livestock management
Course Code	MBT-6204
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026 - 27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• Understand the principles of modern agriculture, integrated farming systems, and sustainable practices. • Implement modern livestock breeding for high-yielding, disease-resistant animals. • Integrate agricultural biotechnology, precision agriculture, smart farming, and digital tools for crop and livestock productivity. • Comprehend agricultural economics, policies, and technology transfer mechanisms for sustainable farm management.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the fundamentals of modern agriculture, integrated farming systems, and sustainable agriculture principles.	PSO1, PSO3, PSO7

	CO 2. Analyze precision agriculture strategies, smart farming systems, and use of IoT, GIS, drones, and AI in agriculture.		PSO2, PSO3, PSO4	
	CO 3. Evaluate livestock breeding, reproductive management, nutrition, and health interventions for high productivity.		PSO1, PSO5, PSO6	
	CO 4. Apply veterinary therapeutics, responsible drug usage, molecular diagnostics, and ethical principles in animal care.		PSO2, PSO6, PSO7	
	CO 5. Make informed decisions combining crop, livestock, veterinary, and technological strategies for sustainable and productive agriculture.		PSO5, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	***Introduction to Modern Agriculture & its Components*** • Global food security challenges, Green Revolution vs. Sustainable Agriculture • Integrated Farming Systems (IFS) ***Soil Health Management*** • Modern soil testing methods • Bio-fertilizers and bio-pesticides • Regenerative agriculture principles ***Water Management*** • Modern irrigation techniques (Drip, Sprinkler, Micro-irrigation, Rainwater harvesting) ***Integrated Pest and Disease Management*** • Biological control agents • Pest surveillance and forecasting • New-generation pesticides • Biosecurity in crop fields. ***Organic and Natural Farming***	**15**	CO1	K1, K2

	• Principles and practices of organic certification • Zero Budget Natural Farming • Compost and vermicomposting technologies			
Module 2:	***Precision Agriculture (PA) & Smart Farming*** • Concept, components (GIS, GPS, Remote Sensing • Sensors and IoT in Agriculture • Real-time data collection and analysis • Automated farm operations and monitoring ***Agricultural Robotics and Automation*** • Autonomous tractors, Robotic harvesters. • Automated seeding and weeding systems. ***Drones and AI in Agriculture*** • Aerial surveying, Crop health monitoring • Disease and pest diagnosis using Machine Learning.	**15**	CO2	K3, K4
Module 3:	***Modern Livestock Production and Management*** • High-yielding indigenous breeds (Cattle, Buffalo, Sheep, Goat, Pig) • Formulation of balanced and economic rations ***Reproductive Management Technologies*** • Artificial Insemination (AI) techniques • Embryo Transfer Technology • In Vitro Fertilization ***Disease Prevention and Control*** • Principles of vaccination • Diagnosis and control of major bacterial, viral, and parasitic diseases (e.g. Brucellosis, Rabies, Parasitism), Zoonotic diseases.	**15**	CO3	K3, K4, K5

	• Molecular diagnostic techniques (PCR)			
Module 4:	***Veterinary Therapeutics*** • Responsible use of antimicrobials • Herbal veterinary medicine ***Animal Welfare and Ethics*** • Humane handling and transportation • Ethical considerations in modern farming ***Agricultural Economics*** • Economics of crop and livestock production • Supply chain and market linkages ***Technology Transfer and Policies*** • Government schemes for modern agriculture and livestock • Regulations on Genetically Modified Organisms	**15**	CO4, CO5	K3, K5, K6
Pedagogy:	Lectures/tutorials/assignments/models			
Texts:	1. Balasubramanian, S., Natarajan, G., & Chelliah, P. R. (2024). *Intelligent robots and drones for precision agriculture*. Springer Nature.			
References/ Readings:	2. Banhazi, T. M., Halas, V., & Maroto-Molina, F. (Eds.). (2022). *Practical precision livestock farming*. Wageningen Academic Publishers. 3. Belák, S., & Pestana, E. (Eds.). (2014). *Veterinary infection biology: Molecular diagnostics and high-throughput strategies*. Springer Nature. 4. Bhattacharyya, P., & Chakraborty, G. (2020). *Organic and natural farming: Concepts and practices*. New India Publishing Agency. 5. Food and Agriculture Organization of the United Nations. (2018). *Precision agriculture: Technologies for sustainable farming systems*. FAO. 6. Kaushik, P., & Kumar, S. (Eds.). (2023). *Agricultural policy, technology transfer, and sustainability in the global south*. Springer Nature.			

	7. Khatri, N., Vyas, A. K., Iwendi, C., & Chatterjee, P. (2024). *Precision agriculture for sustainability: Use of smart sensors, actuators, and intelligent systems*. CRC Press. 8. Krishnan, S., Rose, B. R., Narayanan, R., & Prasanth, B. (Eds.). (2023). *Cloud IoT systems for smart agricultural engineering*. CRC Press. 9. Lal, R. (2020). *Soil health and climate change*. Springer Nature. 10. Mandal, S. C. (2025). *Textbook of veterinary parasitology*. Springer Nature. 11. Mukhopadhyay, C. S., Choudhary, S., Panwar, P. S., & Malik, Y. S. (Eds.). (2023). *Biotechnological interventions augmenting livestock health and production*. Springer Nature. 12. Pathak, A., & Sharma, R. (2023). *Advanced molecular techniques in animal disease diagnosis*. New India Publishing Agency. 13. Singh, K., & Sharma, R. (2020). *Agricultural economics and farm management*. Kalyani Publishers. 14. Yata, V. K., Mohanty, S., & Lichtfouse, E. (Eds.). (2021). *Sustainable agriculture reviews: Animal biotechnology for livestock production* (Vol. 54). Springer Nature. 15. Zhang, Z., Liu, H., & Yang, C. (Eds.). (2023). *Unmanned aerial systems in precision agriculture: Technological progresses and applications*. Springer Nature.

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Title of the Course	Scuba Diving
Course Code	MBT-6205
Number of credits	2
Theory/Practical	Skill based
Level	500
Effective from AY	2026-27
New Course	No
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Students must know how to swim 200 meters (any style) and be able to float for 10 minutes	
Course Objectives:	The course aims to provide students with a comprehensive understanding of the scientific, technical, and practical principles underlying safe and effective scuba diving. It introduces the physics and physiology of diving, familiarizes learners with essential equipment and procedures, and develops competence in dive planning, execution, and environmental awareness. Through both theoretical learning and practical sessions, students will gain hands-on experience in underwater communication, buoyancy control, safety management, and marine appreciation. The course further encourages responsible diving practices, promoting sustainability and respect for the underwater ecosystem while preparing students for advanced scuba certifications or professional aquatic research applications.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the fundamental principles of diving theory, including the physics and physiology that influence underwater activities.	PSO1, PSO2

	CO 2. Identify and operate standard scuba diving equipment, demonstrating knowledge of safety checks, maintenance, and proper usage.		PSO2, PSO5	
	CO 3. Plan and execute safe dives by applying principles of depth, pressure, buoyancy, and gas management, along with decompression and emergency procedures.		PSO2, PSO4, PSO5	
	CO 4. Demonstrate essential diving skills in pool and open-water environments, including buoyancy control, underwater communication, and team coordination.		PSO2, PSO4, PSO7	
	CO 5. Evaluate underwater environments and practice ecologically responsible diving, fostering awareness of marine ecosystems and sustainable diving ethics.		PSO6, PSO7	
Content		**No. of hours**	**Mapped to CO**	**Cognitive Level**
Module I	**Dive Theory** • Introduction • Diving equipment • Physics • Physiology • Planning dives • Executing dives • The underwater world • Scuba experience and beyond	**15**	CO1, CO2	K1, K2, K3
Module II	**Practicals (Total 4 dives)** • Two sessions of pool training for skills • Two days of two sea dives each - skills and pleasure dives	**15**	CO3, CO4, CO5	K2, K4
Pedagogy	Lecture, Tutorial, Practical onsite training			
References/Readings	1. **PADI. (2016).** *Advanced Open Water Diver Manual*. PADI. 2. **Graver, D. (2016).** *Scuba Diving*. Human Kinetics. 3. **Cole, B., & Michael, S. (2020).** *Reef Life: A Guide to Tropical Marine Life*. Firefly Books.			

Title of the Course	Microbiome
Course Code	MBT-6206
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	• To understand the diversity, structure, and ecological principles governing microbiomes across human, plant, animal, and environmental systems. • To elucidate the roles of microbiomes in health, nutrition, biogeochemical cycling, and ecosystem functioning. • To analyze the mechanisms and consequences of dysbiosis and host-microbe interactions in disease and stress conditions. • To explore advanced tools, engineering strategies, and translational applications of microbiome research for sustainable biotechnology solutions.	
Course Outcomes:	At the end of the course students will be able to:	**Mapped to PSO**
	CO 1. Describe and differentiate the composition and ecological dynamics of human, plant, animal, and environmental microbiomes.	PSO1

	CO 2. Explain the physiological and functional roles of microbiomes in health, nutrition, and environmental processes.		PSO1	
	CO 3. Analyze the impact of dysbiosis, environmental perturbations, and anthropogenic factors on microbial community structure and function		PSO1, PSO3	
	CO 4. Evaluate microbiome-based technologies, engineering strategies, and emerging trends for therapeutic, agricultural, and industrial applications.		PSO1, PSO6, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**<u>Introduction & Human Microbiome</u>** ***Introduction:*** • Definitions: microbiota vs microbiome, holobiont, metagenome. • Historical milestones (Koch to Human Microbiome Project). • Community ecology concepts: assembly, resilience, core vs variable microbiome. • Taxonomic Components: Bacteria, archaea, fungi (mycobiome), viruses (virome), protists; strain-level variation and significance. ***Human Microbiome Sites & Functions*** • Gut: composition, metabolic functions, SCFAs, vitamin synthesis. • Skin, oral, respiratory, urogenital microbiomes — ecological niches and host interactions. • Microbiome development: birth, infancy, adulthood, aging. ***Dysbiosis & Disease Associations*** • Mechanisms of dysbiosis; links to metabolic disease, IBD, allergies, neuropsychiatric disorders, oncobiome concepts. • Antibiotics, diet, lifestyle, host genetics. ***Therapeutic Modulation*** • Probiotics, prebiotics, synbiotics, postbiotics, and FMT: principles, evidence, risks.	**15**	CO1, CO2, CO3	K1, K2, K3, K4

	• Microbiome diagnostics and biomarkers.			
Module 2:	**<u>Plant & Animal Microbiomes</u>** ***Plant Microbe functional interactions*:** • Holobiont and phytobiome. Rhizosphere, rhizoplane, endosphere, phyllosphere, seed microbiome. • Community assembly: root exudates, vertical vs horizontal transmission. • Nutrient acquisition: N-fixation, P solubilization, siderophores. • Mycorrhizae (AMF vs ECM), PGPR mechanisms (IAA, ACC deaminase). • Microbiome roles in stress tolerance (drought, salinity, heavy metals) and disease suppression. ***Animal Microbiomes:*** • Comparative gut microbiomes: ruminants, monogastrics, fish, insects. • Rumen microbiology, methanogenesis, fish gut and aquaculture implications. • Host–microbe co-evolution, immunity, nutrition.	**15**	CO1, CO2, CO3	K2, K3, K4
Module 3:	**<u>Environmental Microbiomes</u>** ***Soil Microbiomes:*** • Composition, role in C/N/P/S cycles, rhizosphere versus bulk soil. • Soil health indicators and microbiome responses to agriculture and pollution. • Bioremediation examples and microbial processes for pollutant degradation. ***Freshwater & Marine Microbiomes:*** • Planktonic vs particle-attached microbes; microbial loop; phytoplankton–bacteria interactions. • Coral, sponge, seaweed holobionts; microbial roles in reef resilience and bleaching. ***Built Environment & Airborne Microbiomes:*** • Human-built environment microbiomes (hospitals, homes, ships): exchange with humans and health implications.	**15**	CO1, CO2, CO3	K2, K3, K4

Module 4:	**<u>Tools, Technologies & Applications</u>** ***Key methodologies:*** • Molecular and Sequencing-Based Approaches • Bioinformatics and Data Integration ***Microbiome Engineering & Therapeutics:*** • Synthetic communities, designer consortia, microbiome editing. • Phage therapy, bacteriocins, and targeted modulation strategies. ***Applications & Translation:*** • Precision medicine, diagnostics, agricultural products, bioremediation commercialization, regulatory & ethical issues. ***Emerging Trends & Future Direction:*** • Microbiome-AI integration, microbiome big data, policy and global consortia.	**15**	CO4	K3, K4, K5
Pedagogy:	Lectures/ tutorials/ assignments/group discussion			
Texts:	1. **Adetunji, C. O., Michael, O. S., Esiobu, N., & Aluko, R. E. (Eds.). (2024).** *An introduction to the microbiome in health and diseases*. Academic Press. 2. **Dhanasekaran, D., Paul, D., Amaresan, N., Sankaranarayanan, A., & Shouche, Y. S. (Eds.). (2021).** *Microbiome-host interactions*. CRC Press. 3. **Douglas, A. E. (2018).** *Fundamentals of microbiome science: How microbes shape animal biology*. Princeton University Press.			
References/ Readings:	1. Alexandrescu, L., Tofolean, I. T., Condur, L. M., Tofolean, D. E., Nicoara, A. D., Serbanescu, L., & Stanigut, A. M. (2025). Smart Microbiomes: How AI Is Revolutionizing Personalized Medicine. *Bioengineering*, *12*(9), 944. 2. Bai, X., Huang, Z., Duraj-Thatte, A. M., Ebert, M. P., Zhang, F., Burgermeister, E., & Zuo, T. (2023). Engineering the gut microbiome. *Nature Reviews Bioengineering*, *1*(9), 665-679. 3. Compant, S., Samad, A., Faist, H., & Sessitsch, A. (2019). A review on the plant microbiome: ecology, functions, and emerging trends in microbial application. *Journal of advanced research*, *19*, 29-37. 4. D'Urso, F., & Broccolo, F. (2024). Applications of artificial intelligence in microbiome analysis and probiotic interventions—An overview and perspective based on the current state of the art. *Applied Sciences*, *14*(19), 8627.			

	5. Garn, H., Bahn, S., Baune, B. T., Binder, E. B., Bisgaard, H., Chatila, T. A., ... & Renz, H. (2016). Current concepts in chronic inflammatory diseases: interactions between microbes, cellular metabolism, and inflammation. *Journal of Allergy and Clinical Immunology*, *138*(1), 47-56. 6. Gilbert, J. A., Blaser, M. J., Caporaso, J. G., Jansson, J., Lynch, S. V., & Knight, R. (2018). *Current understanding of the human microbiome. Nature Medicine / NPJ*, retrieved via PMC. PMCID: PMC7043356 7. Ma, Z., Zuo, T., Frey, N., & Rangrez, A. Y. (2024). A systematic framework for understanding the microbiome in human health and disease: from basic principles to clinical translation. *Signal Transduction and Targeted Therapy*, *9*(1), 237. 8. Zhou, T., & Zhao, F. (2025). AI-empowered human microbiome research. *Gut*.

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Title of the Course	Marine Bioremediation and Pollution Monitoring
Course Code	MBT-6207
Number of credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2026-27
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	The course aims to provide students with an in-depth understanding of marine pollution, its sources, types, and ecological impacts on diverse aquatic ecosystems. It introduces the fundamental principles and mechanisms of bioremediation, emphasizing the roles of marine microorganisms and biotechnological innovations in the degradation of pollutants. Students will gain insight into various pollution monitoring approaches, including chemical, biological, and molecular tools, as well as emerging technologies. The course also familiarizes learners with international and national regulatory frameworks, highlighting their significance in sustainable marine management.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explain the sources, types, and ecological impacts of marine pollutants on diverse aquatic ecosystems.	PSO1, PSO2, PSO6
	CO 2. Analyze the mechanisms and microbial pathways involved in the bioremediation of various marine pollutants.	PSO1, PSO4, PSO8

	CO 3. Evaluate the use of physical, chemical, biological, and molecular tools for marine pollution monitoring.		PSO2, PSO3	
	CO 4. Assess the role of biosensors, molecular assays, and biotechnological innovations in pollution detection and mitigation.		PSO2, PSO4, PSO8	
	CO 5. Appraise global and national environmental policies and propose sustainable marine bioremediation strategies.		PSO4, PSO6, PSO7	
Content		**No. of Hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Marine Pollution and Its Impact** **1. Marine Pollutants:** Sources and Types Agricultural runoff, industrial discharge, marine litter, Eutrophication and algal blooms; Plastic and microplastic pollution; Oil spills and hydrocarbon pollutants; Heavy metals and metalloids (Hg, Cd, Pb, As) and radioactive materials; Persistent organic pollutants, Ballast water and bio-invasion. **2. Impacts on Marine Ecosystems** Effects on coral reefs, mangroves, and seagrass beds; Bioaccumulation and biomagnification in food webs; biofouling, bioadhesion, anaerobiosis; Changes in species diversity and population dynamics; Synergistic and antagonistic effects of pollutant mixtures on marine life forms.	**15**	CO1, CO2	K1, K2
Module 2:	**Bioremediation Mechanisms** **1. Fundamentals of Bioremediation** • Principles and stages: biotransformation, mineralization • Intrinsic vs engineered bioremediation • Biostimulation and bioaugmentation **2. Marine Microbial Players** • Hydrocarbon-degrading bacteria (e.g., Alcanivorax, Pseudomonas, Marinobacter) • Fungi and algae in pollutant degradation • Anaerobic vs aerobic degradation pathways	**15**	CO2, CO3	K3, K4, K5

	3. Pollutant-Specific Biodegradation • Petroleum hydrocarbons • Polycyclic aromatic hydrocarbons (PAHs) • Pesticides and pharmaceuticals (emerging contaminants) • Plastic and microplastic degradation enzymes (PETase, laccases) **4. Genetic Engineering in Marine Bioremediation** • Use of genetically modified microbes • CRISPR and synthetic biology in enhancing degradation • Biosafety and bioethics concerns **5. Case Studies** • Deepwater Horizon oil spill • Plastic degrading bacteria in marine environments • Bioremediation of ballast water.			
Module 3:	**Pollution Monitoring Tools and Regulations** **1.** Chemical and Physical Monitoring • Sampling techniques (water, sediment, biota) • Physico-chemical parameters (DO, pH, salinity, turbidity) • Detection of metals, hydrocarbons, nitrates, phosphates **2. Biological Monitoring** • Use of indicator species (mussels, bivalves, foraminifera) • Biomarkers of exposure (e.g., metallothioneins, cytochrome P450 enzymes) • Bioassays and toxicity tests (e.g., algal growth inhibition test) **3. Molecular and Biotechnological Tools** • Environmental DNA (eDNA), qPCR, and metagenomics • Biosensors: microbial, enzymatic, immunosensors • Microarrays and omics-based monitoring approaches **4. Remote and Real-time Monitoring** • Autonomous sensors and underwater robots • GIS-based pollution mapping • Role of AI and data analytics in pollution prediction.	**15**	CO3, CO4	K4, K5
Module 4:	**1. Applied Aspects of Marine Bioremediation**	**15**	CO5	K5, K6

	• Aquaculture effluent management • Restoration of coral reef and mangrove ecosystems • Management of ballast water and shipyard pollution **2. Environmental and Regulatory Frameworks** • MARPOL Convention and UNCLOS • National Coastal Regulation Zone (CRZ) norms • Blue economy and sustainable development goals (SDG 14) • Community-based participatory monitoring **3. Limitations and Prospects of Marine Bioremediation** • Environmental variability and microbial survival • Risk of invasive or genetically modified organisms.			
Pedagogy	Lecture, Tutorial, Assignments, Presentations			
Texts	1. Atlas, R. M., & Bartha, R. (2013). *Microbial ecology: Fundamentals and applications*. Pearson Education. 2. Dash, S. P. (2018). *Marine biotechnology: Applications of molecular biology and marine genetics*. Springer Nature Singapore. 3. Hester, R. E., & Harrison, R. M. (Eds.). (2017). *Marine pollution and human health*. Royal Society of Chemistry. 4. Munn, C. (2019). *Marine microbiology: Ecology & applications*. CRC Press.			
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