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

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GU/Acad –PG/BoS -NEP/2025-26/347 Date: 20.08.2025

CIRCULAR

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

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

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

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.08.20 11:24:20 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,
1. The Dean, School of Earth, Ocean and Atmospheric Sciences, Goa University.
2. The Vice-Dean (Academic), School of Earth, Ocean and Atmospheric Sciences, Goa University.

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

GOA UNIVERSITY

MASTER OF SCIENCE IN MARINE MICROBIOLOGY

(Effective from the Academic Year 2025-26)

ABOUT THE PROGRAMME

The School of Earth, Ocean and Atmospheric Sciences (SEOAS) offers a two-year full time M.Sc. Marine Microbiology program. This Program was initiated in June 2012, under the award of UGC sponsored 'Innovative Program for teaching and research in interdisciplinary and emerging areas'.

The Program is meant for students to pursue higher studies in Marine Microbiology. Being an University in coastal state of India, Goa University provides a strategic advantage in learning microbiology of marine and coastal ecosystems. It serves to impart advanced training to students in the field of Marine Microbiology with focus on marine microbial diversity, bioprospecting and applications of marine microbes in the production of various biologically significant metabolites; and in bioremediation of polluted environments. Students undergo hands-on training with state-of-the art technologies and are trained so as to develop an aptitude for independent research. The Program equips students for higher research leading to the Ph.D. degree in India or in International Universities overseas, or for employment in Research Institutes, in teaching, and in Industry, the students finding speedy employment.

Eligibility: B.Sc. Microbiology, B.Sc. Biotechnology.

OBJECTIVES OF THE PROGRAMME

- The programme is designed to offer comprehensive knowledge of the diverse aspects of microbiology within marine ecosystems.
- Fieldwork and laboratory studies will enable students to explore various marine habitats and understand their conservation. Through hands-on sampling, laboratory analysis, and data interpretation, students will develop essential skills in scientific inquiry and effective communication of their findings.

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

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	**Gain** in-depth knowledge on various aspects of microbiology in marine ecosystems.
PSO 2.	**Develop** analytical skills in marine microbial diversity and ocean systems.
PSO 3.	**Use** ethical practices to enhance professional integrity.
PSO 4.	**Assess** sustainable bioprospecting methods for harnessing social and environmental benefits.
PSO 5.	**Communicate** scientific information and its multidisciplinary implications effectively.

PROGRAMME STRUCTURE
Master of Science in Marine Microbiology
Effective from Academic Year 2025-2026

Bridge Course				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	MMI-1000	Introductory Microbiology and Microbial Techniques	2	100

Semester I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	MMI-5000	Concepts in Oceanography	3	400
2	MMI-5001	Practicals in Oceanography	1	400
3	MMI-5002	Microbial Biochemistry	3	400
4	MMI-5003	Practicals in Microbial Biochemistry	1	400
5	MMI-5004	Microbial Taxonomy and Systematics	3	400
6	MMI-5005	Practicals in Microbial Taxonomy and Systematics	1	400
7	MMI-5006	Biostatistics	3	400
8	MMI-5007	Practicals in Biostatistics	1	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**	**Credits**	**Level**
1	MMI-5201	Estuarine Ecosystems and Microbes	3	400
2	MMI-5202	Practicals in Estuarine Ecosystems & Microbes	1	400
3	MMI-5203	Microbial Pathogens of Fish and Shellfish	3	400
4	MMI-5204	Practical in Microbial Pathogens of Fish and Shellfish	1	400
5	MMI-5205	Marine Mycology	3	400
6	MMI-5206	Practicals in Marine Mycology	1	400
Total Credits for DSE Courses in Semester I			**4**	
Total Credits in Semester I			**20**	

Semester II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	MMI-5008	Industrial Microbiology	3	500
2	MMI-5009	Practicals in Industrial Microbiology	1	500
3	MMI-5010	Microbial Genetics	3	500
4	MMI-5011	Practicals in Microbial Genetics	1	500
5	MMI-5012	Microbial Ecology	3	500
6	MMI-5013	Practicals in Microbial Ecology	1	500
7	MMI-5014	Analytical Techniques in Microbiology	3	500
8	MMI-5015	Practicals on Analytical Techniques in Microbiology	1	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**	**Credits**	**Level**
1	MMI-5207	Marine Extremophilic Microorganisms	3	400
2	MMI-5208	Practicals on Marine Extremophilic Microorganisms	1	400
3	MMI-5209	Marine Virology	3	400
4	MMI-5210	Practicals in Marine Virology	1	400
5	MMI-5211	Archaea	3	400
6	MMI-5212	Practicals on Archaea	1	400
7	MMI-5213	Microbial Physiology and Interactions	3	400
8	MMI-5214	Coral Ecosystem and Associated Microbiota	3	400
9	MMI-5215	Field Trip/Study Tour – Practical	1	400
Total Credits for DSE Courses in Semester II			**4**	
	Total Credits in Semester II		**20**	

BRIDGE COURSE

Title of the Course	Introductory Microbiology and Microbial Techniques
Course Code	MMI-1000
Number of Credits	2
Theory/Practical	Theory
Level	100
Effective from AY	2025-26
New Course	Yes
Bridge Course	Yes
Course for advanced learners	No

Pre-requisites for the Course:	Graduate in any science stream except Microbiology and Biotechnology	
Course Objectives:	To provide a foundational understanding of microbiological techniques in marine microbiology.	
Course Outcomes:		**Mapped to PSO**
	CO 1. To understand the different microbial groups	PSO 1, PSO2
	CO 2. To familiarize with microbiological techniques	PSO 1, PSO2
	CO 3. To apply microscopic techniques	PSO 1, PSO2
	CO 4. To learn microbial growth analyses methods.	PSO 1, PSO2

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Binomial nomenclature; General characteristics of different groups: viruses, viroids, archaea and eubacteria, Eukarya: algae, fungi and protozoa, and prions; Bacteriological techniques: Pure culture isolation: streaking, serial dilution and plating methods; cultivation of aerobic and anaerobic, maintenance and preservation of pure cultures, colony characteristics; Sterilisation: Autoclave (moist heat), hot air oven (dry heat), pasteurization, Tyndallization, membrane filtration	**15**	CO1, CO2	K1, K2
Module 2:	Microscopy: Bright Field, Dark field Phase contrast, electron microscopy – SEM, TEM; stains, mordants, fixatives and decolorisers; Types of staining: Gram staining, monochrome staining and negative staining, special staining methods, differential staining methods, staining of cellular structures, motility of cells by hanging drop technique; Measurements of microbial growth: TVC, direct count, absorbance; bacterial growth curve	**15**	CO3, CO4	K1, K2
Pedagogy:	Lectures/assignments/self-study			
References/ Readings:	1. Atlas R. M. (2020) Principles of Microbiology. 2nd Edition. WM.T. Brown Publishers. 2. Cappucino J. G. & Sherman N. (2014) Microbiology: A Laboratory Manual. 10th Edition. Pearson Education Limited 3. Madigan M.T., Martinko J.M., Dunlap P.V. & Clark D.P. (2017) Brock Biology of Microorganisms. 14th Edition. Pearson International Edition 4. Pelczar M.J., Chan E.C.S. & Krieg N.R. (2001) Microbiology. McGraw Hill Book Company. 5. Salle A.J. (2007) Fundamental Principles of Bacteriology. Dodo Press. 6. Stanier R.Y., Ingraham J.L., Wheelis M.L., & Painter P.R. (1999) General Microbiology. 5th Edition. McMillan 7. Tortora G.J., Funke B.R. & Case C.L. (2018) Microbiology: An Introduction. 13th Edition. Addison-Wesley 8. Wiley J.M., Sherwood L.M. & Woolverton C.J. (2019) Prescott's Microbiology. 11th Edition. McGraw Hill International			

SEMESTER I

Discipline Specific Core Courses

Title of the Course	Concepts in Oceanography
Course Code	MMI-5000
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 a foundational understanding of physical, chemical, geological, and biological processes in the ocean, essential for advanced studies in marine microbiology.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Describe the physical, chemical, geological, and biological features of oceans.	PSO 1, PSO2
	CO 2. Explain the major oceanographic processes, such as currents, tides, and circulation.	PSO 1, PSO2
	CO 3. Explain the geological time scale and the composition of seawater.	PSO 1, PSO2

	CO 4. Describe the different marine habitats and explain primary and secondary productivity.		PSO 1, PSO2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Origin of oceans - physical properties of the sea: temperature, salinity, density - mixed layer depth - ocean circulation: wind-driven and thermohaline circulation - ocean currents - water mass - Coriolis effect - upwelling - Ekman transport - tides - atmospheric circulation - albedo - land-sea breeze - Indian monsoon - El Niño - La Niña - Southern Oscillation - Indian Ocean Dipole	**15**	CO1, CO2	K2
Module 2:	Geological time scale - plate tectonics and seafloor spreading - sediment types - elemental composition of seawater - salinity and chlorinity - residence time of elements - dissolved gases: carbon dioxide and oxygen - nutrients - carbonate system - pH and alkalinity - calcium carbonate precipitation and dissolution - carbonate compensation depth - lysocline	**15**	CO3	K2
Module 3:	Habitat: estuaries, mangroves, wetlands, rocky, sandy intertidal, coral reefs, seagrass, kelps, mudflats, coastal and open ocean, hydrothermal vents - marine zonation - pelagic and benthic communities - marine photosynthesis - phytoplankton and primary production - Redfield ratio - gross and net productivity - new and regenerated productivity - f ratio - pigments - zooplankton and benthic production - measurement and control of secondary production - exclusive economic zone	**15**	CO4, CO5, CO6	K2
Pedagogy:	Lectures/assignments/field trip			
References/ Readings:	1. Gross, M.G. (1990). Oceanography: a view of the Earth. Prentice-Hall, New York. 2. Miller, C.B. and Wheeler, P.A. (2012). Biological oceanography, Wiley-Blackwell Publishers, Oxford. 3. Munn, C.B. (2019). Marine microbiology: ecology and applications. CRC Press, Florida. 4. Pickard, G.L. and Emery, W.J. (1990). Descriptive physical oceanography: an introduction. Pergamon Press, U.K. 5. Sverdrup, H.U. Johnson, M.W. and Flemming, R.H. (1962). The ocean: their physics, chemistry and general biology, - Prentice-Hall, New York. 6. Thurman, H.V. (1988). Introductory Oceanography. Merrill Publishing, Columbus, Ohio			

Title of the Course	Practicals in Oceanography
Course Code	MMI-5001
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 train students in standard oceanographic techniques for the quantitative estimation of key physicochemical and biological parameters in seawater using titrimetric and spectrophotometric methods.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Recall the principles behind titrimetric and spectrophotometric methods used in seawater analysis.	PSO 1, PSO 2
	CO 2. Explain the significance of parameters such as salinity, pH, dissolved oxygen, nutrients, and chlorophyll *a* in marine environments.	PSO 1, PSO 2
	CO 3. Perform laboratory experiments to estimate salinity, dissolved oxygen, nutrients, and chlorophyll *a* concentration.	PSO 1, PSO 2

	CO 4. Interpret experimental data to assess the chemical and biological status of seawater samples.		PSO 1, PSO 2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
1	Demonstration of sampling gears, CTD, grabs, Secchi disk	**2**	CO2	K2, K3
2	Estimation of seawater salinity and pH	**6**	CO1, CO2, CO3, CO4	K1, K2, K3, K4
3	Determination of dissolved oxygen of seawater using Winkler's method	**4**	CO1, CO2, CO3, CO4	K1, K2, K3, K4
4	Determination of phosphate by the spectrophotometric method	**6**	CO1, CO2, CO3, CO4	K1, K2, K3, K4
5	Determination of nitrate/nitrite by the spectrophotometric method	**6**	CO1, CO2, CO3, CO4	K1, K2, K3, K4
6	Determination of chlorophyll *a* by the spectrophotometric method	**6**	CO1, CO2, CO3, CO4	K1, K2, K3, K4
Pedagogy:	Experiments in the laboratory, Field visits			
References/ Readings:	1. Grasshoff, K., Ehrhardt, M. and Kremling, K. (1999). Methods of seawater analysis. Verlag Chemie, Weinheim. 2. Parsons, T.R., Maita, Y. and Lalli, C.M. (1984). A manual of chemical and biological methods for seawater analysis. Pergamon Press, Oxford.			

Title of the Course	Microbial Biochemistry
Course Code	MMI-5002
Number of Credits	3
Theory/Practical	T
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	
CourseObjectives:	To provide in depth knowledge about characteristics, properties and biological significance of the biomolecules of life and energetics and regulation of different metabolic processes in microorganisms.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify various biomolecules and their importance in microbial physiology.	PSO 1
	CO 2. Differentiate various metabolic pathways and study their bioenergetics.	PSO 1, PSO 2
	CO 3. Analyze the regulation of the biochemical pathways.	PSO 2, PSO 4
	CO 4. Discuss various carbon fixation pathways in marine microbes.	PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Biological Molecules: Proteins - Amino acids: features and properties. Protein structure, principles of separation and purification, molecular weight determination; sequencing and synthesis. Carbohydrates- monosaccharides, disaccharides, polysaccharides: types, characteristics, properties. Lipids - Fatty acids: saturated and unsaturated, structure and properties. Cellular composition and significance of biological molecules in microbes.	**15**	CO1, CO2	K1, K2
Module 2:	Metabolic pathways: Carbohydrate metabolism - Central pathways of metabolism – regulatory mechanisms, bioenergetics and significance – EMP, TCA cycle (glucose aerobic and anaerobic metabolism, malate metabolism), Glyoxylate cycle. Gluconeogenesis from TCA intermediates / amino acids / acetyl-CoA; biosynthesis of polysaccharides and sugar interconversions. Lipid Metabolism - Anabolism: Biosynthesis of fatty acids: saturated and unsaturated, triglycerides, phospholipids. Biosynthesis of nitrogenous biomolecules – Nitrogen cycle, Amino Acid and Nucleotide Biosynthetic pathway and their regulation. Deoxyribonucleotides: biosynthesis and regulation. Biosynthesis of nucleotide coenzymes.	**15**	CO2, CO3, CO 4	K3, K4
Module 3:	Electron Transport Chain. Mechanisms involved in Photosynthesis and Chemosynthesis: Photosynthetic Metabolism - Organisms and photosynthetic pigments, fundamental processes in Photosynthesis. Photosynthetic electron transport and photophosphorylation. Alternative pathways for carbon fixation in autotrophs: Calvin Benson cycle, Reverse TCA, Hydroxypropionate pathway. Chemosynthesis - Organisms, substrates, bioenergetics of metabolism. Osmoregulation: Salt-in cytoplasm mechanism, Organic-Osmolyte mechanism, Osmolyte transporters, Osmosensing.	**15**	CO3, CO4	K3, K4
Pedagogy:	Lectures/ assignments			
References/ Readings:	1. Cox M.C., Freeman W.H., & Nelson D.L. (2004). Lehninger Principles of Biochemistry (4th edn), W. H. Freeman & Co. New York. 2. Foster J.W., & Spector M.P. (2002). Microbial Physiology (4th edn), A. John Wiley & Sons Inc. Publication. New York. 3. Kunte H.J. (2006). Osmoregulation in Bacteria: Compatible Solute Accumulation and Osmosensing. Environ.			

	Chem. 3: 94–99. doi:10.1071/EN06016 4. Murray R.K., Bender D.A., Botham K.M., Kennelly P.J., Rodwell V.W. & Weil P.A. (2018). Harper's Illustrated Biochemistry (31st edn), The McGraw- Hill Companies, Inc. NewYork. 5. Voet D., Voet J.G. & Pratt C.W. (2012). Principles of Biochemistry (4th edn), John Wiley and Sons Inc. New York.

Title of the Course	Practical in Microbial Biochemistry
Course Code	MMI-5003
Number of Credits	1
Theory/Practical	P
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:	This course provides opportunities for hands-on experience with microbiological and biochemical concepts in laboratory setup.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Estimate the concentration of various biomolecules.	PSO 1, PSO2
	CO 2. Analyse enzyme activity, specific activity and fold change.	PSO 2
	CO 3. Assess the efficiency of protein purification by salting out and dialysis method.	PSO 3, PSO 4
	CO 4. Design and perform experimental work on extracellular enzymes.	PSO 3, PSO 4

Content:		No of hours	Mapped to CO	Cognitive Level
1	Standard curves for carbohydrates, proteins and lipids, and estimation of unknown biomolecules.	**10**	CO1	K4, K5
2	Enzyme assay (Amylase, Cellulase, Protease, Lipase)	**8**	CO1, CO2	K2, K3, K4
3	Precipitation of protein from solution by salting out and dialysis	**8**	CO3	K1, K2, K3
4	Specific activity, fold purification, percentage yield of enzyme.	**4**	CO4	K4, K5
Pedagogy:	Experiments in the laboratory.			
References/ Readings:	1. Murray R.K., Bender D.A., Botham K.M., Kennelly P.J., Rodwell V.W. & Weil P.A. (2018). Harper's Illustrated Biochemistry (31st edn), The McGraw-Hill Companies, Inc. NewYork. 2. Plummer M.U. & Plummer D.T. (2008). An Introduction to Practical Biochemistry (3rd edn), Tata McGraw Hill Publishing Company. New Delhi.			

Title of the Course	Microbial Taxonomy and Systematics
Course Code	MMI-5004
Number of Credits	3
Theory/Practical	T
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:	This course introduces the development of taxonomy and systematics, the various characters used for this purpose, the rules governing the different taxonomy and classification systems and the salient features of the different microbial groups. It also focuses on the rapidly evolving nature of taxonomy and systematics.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Recognize the dynamic and developing nature of the field of microbial taxonomy and systematics.	PSO 1
	CO 2. Apply knowledge of the standard rules of classification systems to categorize microorganisms.	PSO 1, PSO 2
	CO 3. Describe the recent advances in the fields of taxonomy and classification of microorganisms.	PSO 1, PSO 5

	CO 4. Evaluate the phenotypic, chemotaxonomic and genotypic analysis used in classification of different microbial groups.		PSO 1, PSO 5	
	CO 5. Describe the concept of taxonomic hierarchy in different microbial groups.		PSO 1, POS 5	
	CO 6. Compare the taxonomic characteristics across different microbial groups.		PSO 2, PSO 5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Concepts of taxonomy (characterization, classification and nomenclature), systematics, species, numerical taxonomy and polyphasic taxonomy. Classification of microorganisms, development of classification systems starting from two kingdom to three domain, six-kingdom and 8-kingdom systems; endosymbiotic theory for the origin of eukaryotic organelles. Traditional characters used in classification systems; phenotypic characters - Morphology, Biochemical characterization using Bergey's Manual, Bacteriophage typing, Serotyping.	**15**	CO1, CO2	K1, K2, K3
Module 2:	Nucleic acid-based techniques and chemotaxonomic markers used in classification systems. Nucleic acid-based techniques: PCRs, Restriction Fragment Length Polymorphisms (RFLPs); G+C content (Tm and HPLC); pyrosequencing; 16S rRNA, 18S rRNA and ITS gene sequencing; phylogenetic analysis; DNA-DNA hybridization. Chemotaxonomic markers: Cell wall components, lipid composition, cellular fatty acid (FAME analysis), isoprenoid quinones, activity-based protein profiling and MALDI-ToF analysis.	**15**	CO3, CO4	K2, K3
Module 3:	Salient features of phylum, class and orders with representative examples of the following: Archaea, Eubacteria - Bacteria, Cyanobacteria, Actinomycetes; Mycota; Protista - Algae, Protozoa, Diatoms; and viruses.	**15**	CO5, CO6	K1, K2
Pedagogy:	Lectures/ assignments/ videos.			
References/ Readings:	1. Barlow, A. (ed.) (1992). The Prokaryotes: A Handbook on the Biology of Bacteria: Ecophysiology, Isolation, Identification, Applications, Vol. 1, Springer-Verlag, Germany. 2. Goodfellow, M. & Minnikin, D. E. (1985). Chemical Methods in Bacterial Systematics, The Society for Applied Bacteriology. Technical Series No. 20, Academic Press, London/New York.			

	3. Jean-Michel, C. (2005). Bioinformatics: a beginner's guide. India: Wiley Dreamtech. 4. Kurtzman, C. P., Fell, J. W. & Boekhout, T. (2011). The Yeasts - A Taxonomic Study, Elsevier, Amsterdam. 5. Mordarski, M., Williams, S.T. & Goodfellow, M. (1983). The Biology of the Actinomycetes. Academic Press, London/New York. 6. Ribbons, D. W. & Norris, J. R. (1970). Methods in Microbiology, Vols. 18 & 19, Academic Press, London/New York. 7. Sneath, A. H. P., Mair, S. N. & Sharpe, E. M. (1984). Bergey's Manual of Systematic Bacteriology, Vol. 2, Williams & Wilkins, Academic Press, London/New York. 8. Willey, J. M., Sherwood, L. M. & Woolverton, C. J. (2011). Prescott's Microbiology (10th edn), McGraw Hill, New York.

Title of the Course	Practicals in Microbial Taxonomy and Systematics
Course Code	MMI-5005
Number of Credits	1
Theory/Practical	P
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:	This course provides opportunities for hands-on experience with the microbiological and biochemical techniques used for characterization of different microbial groups.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Develop skills in identification and characterization of different groups of microorganisms.	PSO 2
	CO 2. Use microscopic techniques to identify and classify different groups of microorganisms.	PSO 2
	CO 3. Identify protists using morphological features outlined in standard taxonomic keys.	PSO 2, PSO 4
	CO 4. Identify marine bacterial isolates based on Bergey's Manual of Determinative Bacteriology and 16S rRNA gene sequencing.	PSO 2, PSO 4

Content:		No of hours	Mapped to CO	Cognitive Level
1	Identification of Gram-positive and Gram-negative bacterial isolates by morphological and biochemical tests using standard keys.	**15**	CO1, CO2, CO4	K3, K4
2	Identification of bacteria using 16S rDNA PCR, agarose gel electrophoresis, and sequence analysis.	**5**		
2	Microscopic observation of cyanobacteria.	**2**	CO1, CO2	K3, K4
3	Monochrome staining for visualization of actinomycetes (*Streptomyces* sp.).	**2**	CO1, CO2	K3, K4
4	Wet mount and slide culture technique for yeast (*Saccharomyces cerevisiae/ Schizosaccharomyces pombe*).	**2**	CO1, CO2	K3, K4
5	Morphological characterization of filamentous fungi.	**2**	CO1, CO2	K3, K4
6	Microscopic observation of protists from marine samples.	**2**	CO1, CO2, CO3	K3, K4
Pedagogy:	Experiments in the laboratory.			
References/ Readings:	1. Alexopoulus, C. J., Mims, C. W. & Blackwell, M. (2017). Introductory Mycology. John Wiley & Sons, New Delhi. 2. Barlow, A. (ed.) (1992). The Prokaryotes: A Handbook on the Biology of Bacteria: Ecophysiology, Isolation, Identification, Applications, Vol. 1, Springer-Verlag, Germany. 3. Jean-Michel, C. (2005). Bioinformatics: a beginner's guide. India: Wiley Dreamtech. 4. Kurtzman, C. P., Fell, J. W. & Boekhout, T. (2011). The Yeasts - A Taxonomic Study, Elsevier, Amsterdam. 5. Mordarski, M., Williams, S.T. & Goodfellow, M. (1983). The Biology of the Actinomycetes. Academic Press, London/New York. 6. Simpson, A.G.B., Slamovits, C.H. & Archibald, J.M. (2017). Handbook of the Protists. Springer International Publishing, Germany. 7. Sneath, A. H. P., Mair, S. N. & Sharpe, E. M. (1984). Bergey's Manual of Systematic Bacteriology, Vol. 2, Williams & Wilkins, Academic Press, London/New York.			

Title of the Course	Biostatistics
Course Code	MMI-5006
Number of Credits	3
Theory/Practical	T
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 paper develops concepts about the formulation of experiments, types of data observed in biological experiments, and various statistical operations for handling and processing the data. It covers many mathematical techniques that are useful in understanding and predicting the behaviour of biological systems.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Devise the process for designing a research study.	PSO 2, PSO 3
	CO 2. Acquire skills in data collection, management and quality assurance.	PSO 2, PSO 3
	CO 3. Integrate appropriate statistical procedures to analyse the research data.	PSO 2, PSO 3, PSO 5
	CO 4. Interpret statistical results and communicate the findings effectively.	PSO 2, PSO 3, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Fitting linear models to data, The Basic linear least squares method, Fitting the exponential model by linear least squares; Bacterial growth, steps towards building a mathematical model, Basic models of population growth: exponential and logistic; Nutrient uptake the Michaelis-Menten model and Monod model for growth and external nutrient supply; Analysis of population dynamics – aquatic ecosystem in estuary and ocean viz. Lotka-Volterra Model. Different steps in Research Process. Principles of Experimental Design. Types of sampling designs (Probability and Non-probability). Sampling and Non-sampling error. Validity and reliability of research. Data handling: Population and samples, random samples, parameter and statistics, accuracy and precision, accuracy in observations.	**15**	CO1, CO2	K3
Module 2:	Qualitative and Quantitative data. Types of variables and measurement scales (nominal, ordinal, interval, ratio). Errors in measurement. Tabulation and frequency distribution (relative and cumulative). Descriptive statistics (Measures of central tendency, Measures of dispersion, Skewness, Kurtosis, Correlation analysis – Karl Pearson's Correlation Coefficient, Spearman's Rank Correlation Coefficient, Regression analysis – Linear, Non-linear).	**15**	CO1, CO2, CO3	K5
Module 3:	Theoretical Distribution: Binomial, Poisson, Normal Distributions; Statistical Inference: Hypothesis Testing – parameter and statistics, degree of freedom, confidence limits, testing of hypothesis, test of significance, Type I and Type II error; Large sample tests, Students' T-test, Chi-square test, F-test and ANOVA; Non-parametric tests: Wilcoxon Signed Rank test, Mann-Whitney 'U' test, Kruskal-Wallis 'H' test. Multi-dimensional scaling. Factor Analysis (Principal Component Analysis).	**15**	CO1, CO2, CO3, CO4	K6
Pedagogy:	Lectures/ tutorials/ assignments/ Videos			
References/ Readings:	1. Arora, P.N. and Malhan, P.K. (2012). Biostatistics, Himalaya Publishing House, New Delhi. 2. Danilina, N.I. (1988). Computational Mathematics, Mir Publishers, Russia. 3. Edelstein-Keshet, L. (2017). Differential Calculus for the Life Sciences, The University of British Columbia, Vancouver, Open Book.			

	4. Kothari, C.R. (2013). Quantitative Techniques, Vikas Publishing House, Noida. 5. Kumar, R. (2024). Research Methodology: A step-by-step guide for Beginners. SAGE Publications Pvt. Ltd., 4th Edition., New Delhi. 6. Surya, R.K. (2010). Biostatistics for Health and Life Sciences, Himalaya Publishing House, New Delhi.

Title of the Course	Practicals in Biostatistics
Course Code	MMI-5007
Number of Credits	1
Theory/Practical	P
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:	Handling and processing of biological data for statistical analysis.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Process and analyse data using different statistical tools for its application in microbiology-related experiments.	PSO 2, PSO 4, PSO 5
	CO 2. Use simple regression analysis for examining data related to standard graphs.	PSO 2, PSO 5
	CO 3. Apply normal distribution analysis to appropriate scientific problems.	PSO 2, PSO 5
	CO 4. Analyse biological problems statistically by examining their hypotheses using appropriate tests.	PSO 2, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
1	Statistical analysis and its applications and introduction to various statistical software – Primer, Statistica, Excel	**9**	CO1	K5
2	Linear Regression analysis	**6**	CO2	K5
3	Normal distribution	**6**	CO3	K5
4	Hypothesis testing	**9**	CO4	K5
Pedagogy:	Research papers/Experiments			
References/ Readings:	1. Arora, P. N. and Malhan, P. K. (2012). Biostatistics, Himalaya Publishing House, New Delhi. 2. Kothari, C. R. (2013). Quantitative Techniques, Vikas Publishing House, Noida. 3. Surya, R. K. (2010). Biostatistics for Health and Life Sciences, Himalaya Publishing House, New Delhi. 4. Hammer, Ø., Harper, D. A. T., and Ryan, P. D. (2001). Past: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica, 4(1), 1- 9.			
Web Resources:	1. Basic Tasks in Excel https://support.microsoft.com/en-us/office/basic-tasks-in-excel-dc775dd1-fa52-430f-9c3c-d998d1735fca 2. Grapher User's Guide, 2020 – Golden Software, LLC USA, www.GoldenSoftware.com 3. Surfer 12 Full User's Guide, 2014 - Golden Software, LLC USA, www.GoldenSoftware.com 4. PRIMER: User Manual/Tutorial. PRIMER-E. Plymouth. 5. PAST: https://past.en.lo4d.com/windows#google_vignette			

Discipline Specific Elective Courses

Title of the Course	Estuarine Ecosystems and Microbes
Course Code	MMI-5201
Number of Credits	3
Theory/Practical	T
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 explores the estuarine ecosystem understanding the abiotic and biotic factors playing role in balancing the dynamic system.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Explains the types of estuaries and their physico-chemical characteristics	PSO 1
	CO 2. Analyses the biodiversity of marine organisms and their distribution patterns	PSO 1, PSO 2
	CO 3. Explains the composition of Microflora of estuarine ecosystem, elaborate on the factors affecting and evaluate their interaction with other biota.	PSO 1, PSO 2
	CO 4. Defines Primary productivity and explain food webs in estuarine ecosystem.	PSO 1, PSO 4

	CO 5. Enlists the types of mangroves and describe their role in the estuarine ecosystem		PSO 1, PSO 5	
	CO 6. Compiles the anthropogenic activities affecting estuaries and list the importance of conservation of estuaries		PSO 1, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Estuaries: Definition - Characteristics of estuaries - Origin of estuaries - Structure of an estuary - functions of estuary - Types of estuaries - Some typical estuarine habitats of India (Mandovi, Zuari, Godavari, Krishna, Cauvery) - Estuarine geomorphology - patterns of environmental variability - Physical environmental factors (temperature, light, currents, tides and waves) - Chemical environmental factors (oxygen, carbon dioxide and carbonates, salinity, pH, nutrients) - Classification of marine organisms and their characteristic features - variety and spatial patterns of diversity.	**15**	CO1, CO2	K2, K4
Module 2:	Estuarine microbial ecology – Microorganisms in estuarine water and sediments – Factors influencing estuarine microorganisms - Factors influencing estuarine microorganisms and their adaptations, Interactions with associated biota - Estuarine food webs - Factors affecting primary productivity - Trophic transfer, cascade effects and role of bacterial protoplasm, Biomagnification.	**15**	CO3, CO4, CO5	K1, K2, K3
Module 3:	Role of mangroves, salt marshes and deltas in estuarine ecosystem functioning. Threats to estuarine ecosystems - Natural threats - Anthropogenic threats – Trace metal pollution and bioaccumulation, effluents and introduction of pathogenic bacteria, Conservation of estuaries -Effects on estuarine ecosystem.	**15**	CO6	K3
Pedagogy:	Lectures/assignments/ visit to estuary			
References/ Readings:	1. Balakrishna Nair. N. and Thampy D.M. (1980). A text book of marine ecology. Macmillan, Delhi. 2. Broecker, W.S. (1974). Chemical oceanography. Harcourt, Brace, Jovanivich Inc., New York. 3. Day, J.W., Crump B.C., Kemp W.M., Yanez-Arancibia A. (2013). Estuarine ecology. Wiley-Blackwell Inc., Oxford. 4. Friedrich, H. (1969). Marine Biology. Sidgewick & Jackson, London. 5. Mitra A. and Zaman S. (2016) Basics of marine and estuarine ecology. Springer, India.			

	6. Raymont, J.E.C. (1980). Plankton and productivity in the oceans, Volume 1. Phytoplankton. 2nd Edition. Pergamon, U.K. 7. Sverdrup, H.V., Johnson, M.W., and Fleming, R.H. (1942). The oceans - their physics, chemistry and general biology. Prentice-Hall Inc., U.S.

Title of the Course	Practicals in Estuarine Ecosystems & Microbes
Course Code	MMI-5202
Number of Credits	1
Theory/Practical	P
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 develops the techniques involved in estuarine sample processing and analysis.			
Course Outcomes:			**Mapped to PSO**	
	CO1. Estimate BOD, POC, TOC of estuarine water and sediment samples		PSO 2, PSO 3	
	CO2. Analysis of water samples for bacterial enumeration by microscopy.		PSO 1, PSO 2	
	CO3. Microbial analysis of water and sediment samples		PSO 2, PSO 3	
	CO4. Determine the salinity tolerance of estuarine bacterial isolates.		PSO 1, PSO 2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
1	Chemical characteristics of estuarine water sample – BOD, COD	8	CO1	K4, K5

2	Estimation of suspended load, Particulate Organic Carbon and Total Organic Carbon of estuarine water	8	CO1	K4, K5
3	Bacterial enumeration by microscopy (TVC and TC)	6	CO2	
4	Isolation of bacteria – Total Plate Count	4	CO3	K3, K4, K5
5	Determination of salinity tolerance of selected bacterial isolates	4	CO4	K4, K5
Pedagogy:	Experiments in the laboratory, visit sites for sampling			
References/ Readings:	1. Bull, A.T. (2003). Microbial Diversity and Bioprospecting. ASM Press, Washington, U.S. 2. Chaney, R.C. (1991). Sampling and Preparation of Marine Sediments, In, Foundation Engineering Handbook, Springer Publishers, New York. 3. Green, L.H. and Goldman, E. (2015). Practical Handbook of Microbiology, 3rd Edition. CRC Press, Florida. 4. Kennish, M. J. (2017). Practical Handbook of Estuarine and Marine Pollution, CRC Press, Florida. 5. Kennish, M.J. (2019). Practical Handbook of Marine Science, CRC Press, Florida. 6. Reddy, S.M., Charya, M.A.S. and Girisham, S. (2012). Microbial Diversity: Exploration and Bioprospecting, Scientific Publishers, India. 7. Thomas, T.R., Kavlekar, D.P., Lokabharathi, P.A. (2010). Marine drugs from sponge-microbe association: a review. Marine Drugs, 8: 1417-1468.			

Title of the Course	Microbial Pathogens of Fish and Shellfish
Course Code	MMI-5203
Number of Credits	3
Theory/Practical	T
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:	Develop the knowledge of fishes, fisheries, aquaculture in India. Develop the concepts of various infectious diseases present in fishes and spread through fishes.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Garner knowledge of wide diversity of fisheries in marine and coastal ecosystems.	PSO 1, PSO 2
	CO 2. Analyse fish microbiome, pathogens and their associated antibiotic resistance.	PSO 3, PSO 4
	CO 3. Compare various microbial infections in fishery resources and their implications.	PSO 3
	CO 4. Assess the influence of zoonotic infections and marine toxins on fish and human health.	PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	History of microbial diseases associated with fishes and shellfishes. Role of beneficial vs harmful microbes in fish farms and natural habitats. Microbiome associated with fishes and shellfishes. Symbionts, commensals and parasites. Stress associated shifts in microbiome. Influence of gut microbiome on immunity and growth. Biofilm production and its implications in hatcheries.	**15**	CO1, CO2	K1, K2
Module 2:	Classification of diseases; Detailed study of bacteria pathogenic to finfish and shellfish with emphasis on morphology, epidemiology, pathogenesis, treatment and control: *Flavobacterium, Edwardsiella, Vibrio, Aeromonas, Renibacterium, Yersinia, Mycobacterium.* Viral infections: White Spot Syndrome Virus (WSSV), Monodon Baculo Virus (MBV), Yellow Head virus (YHV), Hepatopancreatic Parvo Virus (HPV), Infectious Hypodermal and Hematopoeitic Necrosis Virus (IHHNV). Ecto and endoparasitic infections. Antibiotic resistance in aquaculture systems. Responsible use of antibiotics and policies. Permissible limits for export. Methods of disease prevention and control: Use of Prebiotics, Probiotics and Phage therapy. Use of Specific Pathogen Free (SPF) and Specific Pathogen Resistant (SPR) species.	**15**	CO2, CO3	K3, K4
Module 3:	Marine toxins: *Paralytic Shellfish Poisoning (PSP) Toxins, Amnesic Shellfish Poisoning (ASP) Toxins, Diarrhetic Poisoning Toxins, Lipophilic Shellfish Toxins (LST), Neurotoxin Shellfish Poisoning (NSP) Toxins, Venerupin shellfish poisoning, Ciguatera toxins, tetradotoxins, Azaspiracids, Cyclic Imines and their origin.*	**15**	CO4	K1, K2, K3
Pedagogy:	Lectures/ assignments/ presentations			
References/ Readings:	1. Hoole D., Buck D., Burgess P., & Welby I. (2011). Diseases of Carps and Other Cyprinid Fishes, Wiley-Blackwell Publishers. New 2. Jersey.Fernandes R. (2009). Microbiology Handbook: Fish and Seafood. RSC Publishing. London. 3. Leatherland J. F. & Wook P. K. T. (2006). Fish Diseases and Disorders (2nd edn) CABI Publishers. United Kingdom.			

	4. Noga E. C. (2010). Fish Disease: Diagnosis and Treatment (2nd edn). Wiley-Blackwell Publishers. New Jersey. 5. Roberts R. J. (2012). Fish Pathology (4th edn). Wiley-Blackwell Publishers. New Jersey. 6. Sindermann C.J. (1970). Principle Diseases of Marine Fish and Shellfish (1st edn). Academic Press of NewYork and London. 7. Woo P. & Bruno D. (2011). Fish Diseases and Disorders, Vol 3: Viral, Bacterial and Fungal Infections (2nd edn) CABI Publishers. United Kingdom.

Title of the Course	Practical in Microbial Pathogens of Fish and Shellfish
Course Code	MMI-5204
Number of Credits	1
Theory/Practical	P
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:	Provides hands-on experience in the fish anatomy and its associated microbial flora, including human pathogens.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply the tools and techniques of microbiology for isolation of fish microbiota.	PSO2, PSO3
	CO 2. Assess the microbiological quality of fishes in terms of associated disease or as carrier for human pathogens.	PSO2, PSO3, PSO4
	CO 3. Analyze the symptoms in diseased moribund fish for the prediction of disease type.	PSO1, PSO2
	CO 4. Evaluate the antibiotic sensitivity of fish pathogens.	PSO5

Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
1	Methods for examining moribund fish from aquaculture/aquarium for diagnosis of disease condition, techniques for diseased tissue collection and processing, and identification of causative agent.	**10**	CO1, CO2	K2, K3
2	One bacterial and viral pathogen identification using PCR and diagnostic kit.	**10**	CO2, CO3	K3, K4
3	Evaluation of Antibiotic sensitivity and MAR index of fish pathogens.	**10**	CO4	K5
Pedagogy:	Experiments in the laboratory.			
References/ Readings:	1. Bauer, A. W., Kirby, W. M. M., Sherris, J. C., & Turck, M. (1966). Antibiotic susceptibility testing by a standardized single disk method. American Journal of Clinical Pathology, 45(4), 493–496. [PMID: 5325707] 2. Krumperman, P. H. (1983). Multiple antibiotic resistance indexing of *Escherichia coli* to identify high-risk sources of fecal contamination of foods. Applied and Environmental Microbiology, 46(1), 165–170. 3. Leatherland J. F. & Wook P. K. T. (2006) Fish Diseases and Disorders (2nd edn) CABI Publishers. United Kingdom. 4. Noga E. C. (2010). Fish Disease: Diagnosis and Treatment (2nd edn). Wiley-Blackwell Publishers. New Jersey. 5. Woo P. & Bruno D. (2011). Fish Diseases and Disorders, Vol 3: Viral, Bacterial and Fungal Infections (2nd edn) CABI Publishers. United Kingdom.			

Title of the Course	Marine Mycology
Course Code	MMI-5205
Number of Credits	3
Theory/Practical	T
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:	This course deals with classification and identification of fungi, their ecology in marine and extreme habitats, and their applications.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Discuss the distribution of fungi in the marine environment.		PSO 1, PSO 4	
	CO 2. Demonstrate fungal growth and development.		PSO 1, PSO 4	
	CO 3. Integrate new technologies in studying physiology, genetics and applications of marine fungi.		PSO 1, PSO 2, PSO 4	
	CO 4. Analyse various biotechnological applications of marine fungi.		PSO 4, PSO 5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	Fungal diversity and distribution: Phylogeny and detailed classification of fungi. Econiches of marine fungi – polyhaline coastal environments (salt marshes, mangroves, estuaries); hypersaline environment (solar salterns, Salt Lake, Dead Sea); oceans and hydrothermal vents. Extremophilic fungi – halophiles, xerophiles, oligotrophs, barophiles, psychrophiles, thermophiles. Techniques to study marine and extremophilic fungi – sample collection and isolation procedures, identification – morphotyping, secondary metabolites, molecular finger printing, FAME, karyotyping, gene sequencing.	**15**	CO 1, CO 2, CO 3	K2
Module 2:	Physiology and genetics: Growth cycle and development. Fungal hormones (attractants), morphogenesis and differentiation. Secondary metabolites – pigments, mycotoxins. Cross over and tetrad analysis. Mating type switching. Deuteromycotina – parasexuality, cytoplasmic inheritance. Fungal associations – symbionts, saprophytes and parasites on higher forms of marine life.	**15**	CO 2, CO 3	K3
Module 3:	Threats and applications: Mycoses – diseases of fish, bivalves and corals. Bioprospecting and bioremediation – industrially important enzymes, secondary metabolites, nutraceuticals, antimicrobials, antitumour agents, pigments. Biodegradation and bioremediation.	**15**	CO 3, CO 4	K4
Pedagogy:	Lectures/assignments/presentations/videos/self-study			
References/ Readings:	1. Alexopoulus, C. J., Mims, C. W., & Blackwell, M. (2017). Introductory mycology. (Fourth Edition), New Delhi: John Wiley & Sons. 2. Borkovich, K. A., & Ebbole, D. J., (2010). Cellular and molecular biology of filamentous fungi. Washington DC: ASM Press. 3. Borse, B. D., Bhat, J. D., Borse, K. N., Tuwar, N. S., & Pawar, N. S. (2012). Marine fungi of India (Monograph), Panaji: Broadway Publishing House. 4. Deacon, J. W. (1984). Introduction to modern mycology. Oxford Blackwell Scientific Publications. 5. Domsch, K. H., Gams, W., & Anderson, T-H., (2007). Compendium of soil fungi. (Second Edition), Eching, IHW-Verlag. 6. Mehrotra, R. S., & Aneja K. R., (1990). An Introduction to Mycology. New Delhi: Wiley Eastern Limited. 7. Moore, D. (2011). 21st Century guidebook to fungi. New York: Cambridge University Press.			

	8. Moore, D., & Frazer, L. A. N. (2002). Essential fungal genetics. New York: Springer Publishers. 9. Onions, A. H. S., Allsop, D., & Eggins H. O. W., (1981). Smith's introduction to industrial mycology. London: Edward Arnold Publishers. 10. Raghukumar, C. (2012). Biology of marine fungi. Springer Publishers, Berlin Heidelberg. 11. Raghukumar, S. (2017). Fungi in coastal and oceanic marine ecosystems. Switzerland : Springer Publishers. doi: 10.1007/978-3-319-54304-8.

Title of the Course	Practicals in Marine Mycology
Course Code	MMI-5206
Number of Credits	1
Theory/Practical	P
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 deals with the isolation and identification of fungi, handling fungal cultures and designing experiments with sporulating and non-sporulating fungi.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Compare various morphological features of fungal cultures for identification to genus level.	PSO 1
	CO 2. Analyse and apply techniques necessary for isolation of fungi from different marine samples.	PSO 2
	CO 3. Design experimental work with fungal cultures on plate as well as in broth.	PSO 2
	CO 4. Assess handling of sporulating and non-sporulating fungal cultures during laboratory studies.	PSO 4, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
1	Study of fungal cultures: colony and morphological characteristics.	6	CO2, CO4	K4, K5
2	Isolation and identification of fungi from marine ecosystem.	10	CO1, CO2, CO4	K4, K5
3	Dye decolourization experiment using marine fungal isolate.	6	CO 3, CO 4	K4, K5
4	Biosorption of heavy metals using live and dead biomass	8	CO 3, CO 4	K4, K5
Pedagogy:	Laboratory experiments/ tutorials			
References/ Readings:	1. Alexopoulus, C. J., Mims, C. W., & Blackwell, M. (2017). *Introductory mycology*. (Fourth Edition), New Delhi: John Wiley & Sons. 2. Borse, B. D., Bhat, J. D., Borse, K. N., Tuwar, N. S., & Pawar, N. S. (2012). *Marine fungi of India (Monograph)*, Panaji: Broadway Publishing House. 3. Dusengemungu, L., Kasali, G., Gwanama, C., & Ouma, K. O. (2020). Recent advances in biosorption of copper and cobalt by filamentous fungi, *Frontiers in Microbiology*, 11, 582016. 4. Lotlikar, N. P., Damare, S. R., Meena, R. M., Linsy, P., & Mascarenhas, B. (2018). Potential of marine-derived fungi to remove hexavalent chromium pollutant from culture broth. *Indian Journal of Microbiology*, 58(2), 182-192. 5. Mehrotra, R. S., & Aneja K. R., (1990). *An Introduction to Mycology*. New Delhi: Wiley Eastern Limited.			

SEMESTER II

Discipline Specific Core Courses

Title of the Course	Industrial Microbiology
Course Code	MMI-5008
Number of Credits	3
Theory/Practical	T
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:	Understanding of concepts in the fermentation processes employed in the industries to produce the products from marine microorganisms.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Define fermentation, differentiate between different types of fermentations.	PSO1
	CO 2. Elaborate on the methods for strain improvement and mutant selection.	PSO1, PSO2, PSO3
	CO 3. Discuss role of rheology, sterilisation parameters for media and types of media.	PSO1

	CO 4. Explain the fermentation monitoring methods and their controls.		PSO1, PSO2, PSO3	
	CO 5. Compare and contrast the different methods for downstream processing of fermentation products.		PSO1, PSO2, PSO3	
	CO 6. Explain the production and application of marine microbial products.		PSO 1, PSO 5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Industrially important marine microorganisms, Fermentation media, Asepsis and sterilisation, growth kinetics – optimization of growth parameters - Bioreactor design and operation: Batch culture, Fed-batch culture and Continuous culture, classification of reactors; designing parameters for reactors (stirred tank reactor, airlift reactor, plug flow reactor) - rheology of fermentation broth - gas-liquid mass transfer, heat transfer, scale up - Solid substrate fermentation (SSF): Principles and application with examples (penicillin, amylase) - Immobilized enzymes and cell systems.	**15**	CO1, CO2, CO3	K1, K2, K3
Module 2:	Fermentation monitor and control: speed, temperature, gas, pH, Dissolved oxygen, foam, redox, air flow, weight, pressure, biomass - On-line and off-line analysis - Layout and components of fermentation process for extracellular and intracellular microbial products - Recovery of biomass (cells and solid particles), cell disruption for recovery of intracellular products, primary isolation (extraction, sorption), precipitation, industrial processes for chromatography and fixed bed adsorption, membrane separations - drying, crystallisation, whole broth processing (Penicillin production) - Formulation, packaging - QC/QA; IPR.	**15**	CO4, CO5	K1, K2, K3
Module 3:	Microbiological techniques in marine food industry, canning, freezing, drying - Industrial production and application – enzymes (proteases, lipases, amylase, pectinase, cellulase), carotenoids, EPS, bioplastics, biopolymers – xanthan, pigments, antibiotics-erythromycin, steroids, SCP, biofuels, introduction to synthetic biology using marine microbial strains – Entrepreneurship.	**15**	CO6	K1-K3
Pedagogy:	Lectures/ assignments/ posters			
Texts:	Stanbury, P.F., Whitaker, A. and Hall S.J. (2016). Principles of fermentation technology. 3rd Edition. Butterworth-			

	Heinemann Publishers, Oxford, U.K.
References/ Readings:	1. Arad, S.M. (1999). Polysaccharides from red microalgae. In, Chemicals from microalgae, Cohen, Z. (Ed.). Taylor and Francis, London. Pp. 282-292. 2. Borowitzka M.A. (1995). Microalgae as sources of pharmaceuticals and other biologically active compounds. Journal of Applied Phycology 7, 3-15. 3. Demain, A.L., Davies, J.E. and Atlas, R.M. (2010). Manual of industrial microbiology and biotechnology. ASM Press, Washington, U.S. 4. Flickinger, M.C. and Drew S.W. (2002). The Encyclopedia of bioprocess technology: Fermentation, biocatalysis and bioseparation. Volumes 1 – 5. John Wiley Publisher, New Jersey. 5. Kopecky J., Schoefs B., Loest K., Stys D. and Pulz O. (2000). Microalgae as a source for secondary carotenoid production: a screening study. Archiv für Hydrobiologie Supplement 133, 153-168. 6. Melis A. and Happe T. (2001). Hydrogen production. Green algae as a source of energy. Plant Physiology 127, 740-748.

Title of the Course	Practicals in Industrial Microbiology
Course Code	MMI-5009
Number of Credits	1
Theory/Practical	P
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:	This course develops the skills for techniques and instrumentation in industrial microbiology.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Describe fermentor design, draw and label different parts of stirred tank reactor.		PSO 1, PSO 2	
	CO 2. Measure and calculate viscosity of substrate solutions using viscometer.		PSO 1 - PSO 3	
	CO 3. Extract and quantitate the exopolysaccharide produced using marine microbial isolate.		PSO 1 - PSO 4	
	CO 4. Isolation and screening of antibiotic producing marine bacteria.		PSO 1 - PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
1	Batch cultivation of bacterial isolates for the production of protease/cellulase enzymes	6	CO 1	K1, K2

	using a stirred tank reactor.			
2	Rheology of culture medium using Ostwald's viscometer.	6	CO 2	K2-K4
3	Exopolysaccharide production using marine microbial isolate.	6	CO 3	K3, K4
4	Downstream processing for EPS.	6	CO 3	K3-K5
5	Screening for antibacterial activity of marine bacteria	6	CO 4	K2-K6
Pedagogy:	Experiments in the laboratory, data collection and processing.			
References/ Readings:	1. Determination of viscosity with Ostwald's viscometer. Materials, Department of Physical Chemistry, Eotvos University, Budapest. 2. Flickinger, M.C. and Drew S.W. (2002). The Encyclopedia of bioprocess technology: fermentation, biocatalysis and bioseparation. Volumes 1 – 5. John Wiley Publisher, New Jersey. 3. Jyoti, K. M., Soni, K. & Chandra R. (2024) Optimization of the production of Exopolysaccharide (EPS) from biofilm-forming bacterial consortium using different parameters. The Microbe, 4: 100117. https://doi.org/10.1016/j.microb.2024.100117. 4. Temmerman, R., Goethals, K., Garmyn, A., Vanantwerpen, G., Vanrobaeys, M., Haesebrouck, F., Antonissen, G., & Devreese, M. (2020). Agreement of Quantitative and Qualitative Antimicrobial Susceptibility Testing Methodologies: The Case of Enrofloxacin and Avian Pathogenic *Escherichia coli*. *Frontiers in Microbiology*, *11*, 570975. https://doi.org/10.3389/fmicb.2020.570975 5. Zaghloul, E. H., & Ibrahim, M. I. A. (2022). Production and characterization of exopolysaccharide from newly isolated marine probiotic *Lactiplantibacillus plantarum* EI6 with *in vitro* wound healing activity. *Frontiers in Microbiology*, *13*, 903363. https://doi.org/10.3389/fmicb.2022.903363			
Web Resources:	1. https://acmeresearchlabs.in/2024/02/03/viscosity-using-ostwald-viscometer-a-detailed-guide 2. https://www.slideshare.net/slideshow/viscosity-measurement-using-ostwald-viscometer/54056547#8 3. https://www.youtube.com/watch?v=XApUZukvbmQ 4. https://www.youtube.com/watch?v=5eKdZ0dVCCo 5. https://www.youtube.com/watch?v=lgDYzUBGlIE 6. https://www.youtube.com/watch?v=slb508vD6l8			

	7. https://www.youtube.com/watch?v=lN3lgusZe8U 8. https://www.youtube.com/watch?v=Aw2yjoZ_RtY

Title of the Course	Microbial Genetics
Course Code	MMI-5010
Number of Credits	3
Theory/Practical	T
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:	This course develops concepts in molecular biology: DNA packaging, DNA damage and repair, gene structure, expression and regulation in both prokaryotes and eukaryotes	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand gene structure and mutations in prokaryotes.	PSO 1
	CO2. Compare positive and negative gene expression and regulation systems.	PSO 3, PSO 4
	CO3. Differentiate various repair mechanisms of DNA damage.	PSO 4
	CO4. Discuss the significance of mutagenesis in molecular research and microbial evolution.	PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to microbial genetics. DNA structure and forms, its fundamental functions, Replication, Transcription, Translation, Genome organisation: Chromosome, structural features, functions, and packaging in the chromatin fibre. Satellite DNA, Repetitive DNA. Histone modifications. Microbial gene transfer (Conjugation, transformation, transduction). Structural and numerical chromosomal aberrations and their significance. Genomic islands. eDNA and metagenomics.	**15**	CO1, CO4	K1, K2
Module 2:	DNA Damage, DNA Repair and Recombination: Types of DNA damage (spontaneous and induced DNA damage). Mutagenesis: Somatic and germinal mutation, site specific using PCR/ cassette mutagenesis, and random mutagenesis. Types of mutation: silent, missense, nonsense, Read through, frameshift- insertion and deletion mutation, translocation, Inversion, suppressor mutation. Mutagenic chemicals and radiations and their mechanism of action: Base analogues (5-Bromouracil and 2-amino purines), EMS, acridines, NTG, Hydroxylamine; mutagenic radiations- UV, X-rays and gamma rays. Ames test; Auxotrophy. Mechanisms/pathways to remove damaged DNA: Excision repair, mismatch repair, recombination repair in *E. coli* and SOS Repair. Role of RecA in DNA damage repair, photoreactivation repair in E. coli involving photolyase. Mechanisms of Genetic Recombination: General and site-specific recombination. Heteroduplex DNA formation (Homologous recombination). Holliday junctions. Synaptonemal Complex, Bacterial RecBCD system and its stimulation of chi sequences.	**15**	CO3, CO4	K3
Module 3:	Genomic rearrangements, Gene structure and control of gene expression in Prokaryotes and Eukaryotes: Mechanism of General and programmed DNA rearrangements, Antigenic and phase variation in bacteria. Transposons: IS elements – Composite transposons (Tn3, Tn10), Ty and P type, Mechanism of transposition. Role of transposons in DNA rearrangements and microbial genome evolution. An overview of Gene expression control, DNA binding motifs in gene regulatory proteins, genetic switches and their role in control of gene expression. Lac operon, tryptophan operon, post-transcriptional controls-transcriptional attenuation, Riboswitches, Alternate	**15**	CO2	K3

	splicing, RNA editing, RNAi.			
Pedagogy:	Lectures/ assignments			
References/ Readings:	1. Alberts B., Johnson A., Lewis J., Morgan D., RaffM., Roberts K.& Walter, P. (2015). MolecularBiology of the Cell (J. Wilson, & T. Hunt, Eds.) (6thedn). W.W. Norton & Company. NewYork. 2. Davis L.G., Dibner M.D. & Battey J. F. (1986). Basic Methods in Molecular Biology, Elsevier. Netherlands 3. Gardner E.J., Simmons M.J. & Snustad D.P. (2015). Principles of Genetics (7th edn) John Wiley & Sons. NewYork. 4. Krebs J. E., Lewin B., Goldstein E. S. & Kilpatrick S.T. (2018). LEWIS Genes XII (1st edn) Jones and Bartlett Publishers. Burlington. 5. Maloy S.R., Cronan J.E. & Freifelder D. (1994). Microbial Genetics (2nd edn) Jones and Bartlett Publishers. Boston. 6. Peter J.R. (2010). iGenetics: A Molecular Approach(3rd edn) Pearson Education. San Francisco. 7. Streips U.N. & Yasbin R.E. (2002). Modern Microbial Genetics (2nd edn). John Wiley & Sons. NewYork. 8. Twyman R.M. (1998). Advance Molecular Biology:A Concise Reference (W. Wisden, Ed.) (1st ed.). Garland Science. London.			

Title of the Course	Practical in Microbial Genetics
Course Code	MMI-5011
Number of Credits	1
Theory/Practical	P
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:	This course provides hands-on experience with DNA extraction, purification and electrophoretic techniques.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Perform genomic/total DNA extraction and PCR amplification in molecular research.		PSO 2, PSO 4	
	CO 2. Compare various DNA extraction protocols and interpret the importance of each step.		PSO 1, PSO 5	
	CO 3. Determine of amplicon size.		PSO 2	
	CO 4. Plan and perform mutagenesis to study induced genetic manipulation.		PSO 2, PSO 3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
1	Isolation of genomic DNA of bacterial cells, estimation of quantity and purity of DNA	10	CO 1, CO 2,	K2, K3,

	by spectrophotometry, and agarose gel electrophoresis.		CO 3	K4
2	Isolation of metagenomic DNA from environmental sample (sediment/ water).	4	CO 1, CO 2	K2, K3, K4
3	Isolation of RNA, estimation of quality and quantity and purity of RNA by spectrophotometry, and agarose gel electrophoresis	6	CO 1, CO 2	K2, K3, K4
4	PCR amplification of a specific gene and agarose gel analysis of PCR product to determine amplicon size.	4	CO 1, CO 3	K5
5	Random mutagenesis using UV and plotting of UV survival curve for pigmented and non-pigmented bacterial strains.	6	CO 4	K2, K5
Pedagogy	Experiments in the laboratory.			
References/ Readings:	1. Davis L.G., Dibner M.D. & Battey J. F. (1986). Basic Methods in Molecular Biology, Elsevier. Netherlands. 2. Kamlage B. (1996). Methods for General and Molecular Bacteriology. Edited by P. Gerhardt, R. G. E. Murray, W. A. Wood and N. R. Krieg. American Society for Microbiology, Washington, D.C. 3. Miller, J. H. (1992). Experiments in Molecular Genetics (11. print). Cold Spring Harbor Laboratory.			

Title of the Course	Microbial Ecology
Course Code	MMI-5012
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	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide an in-depth understanding of marine microbial ecology, focusing on microbial diversity and interactions with environmental factors, their role in biogeochemical cycles, and their responses to climate change and dissolved organic matter dynamics in the ocean.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify the major groups of marine microorganisms and describe their ecological roles in marine ecosystems.	PSO 1, PSO 2
	CO 2. Evaluate the influence of microbial activity on the cycling of carbon, nitrogen, and other key elements in the ocean.	PSO 1, PSO 2
	CO 3. Explain how marine microbes interact with dissolved organic matter and play a role in biogeochemical cycles.	PSO 1, PSO 2

	CO 4. Analyze the impact of climate change on microbial diversity, distribution, and ecosystem processes in marine environments.		PSO 1, PSO 2	
	CO 5. Synthesize the role of marine microorganisms in nutrient cycling and their potential responses to climate change.		PSO 1, PSO 2	
	CO 6. Identify the major groups of marine microorganisms and describe their ecological roles in marine ecosystems.		PSO 1, PSO 2	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Marine microbiome: ecology and function, microbial interaction: mutualism, commensalism, parasitism, microbial symbiosis - microbiomes from plankton, fish, coral, sponge, deep-sea invertebrates, and animals. Biogeochemical cycles: carbon, nitrogen, phosphorus, sulphur, and iron. Anaerobic microbial metabolism: Biogeochemical cycles in the anoxic environment with special reference to OMZs in the world oceans	**15**	CO1, CO2	K1, K3
Module 2:	Trophic interactions - microbial loop, food web dynamics, sources and composition of DOM, reactivity class of DOM, transformations and fate of dissolved organic matter (DOM) - chromophoric dissolved organic matter (CDOM), DOM release and microbial food webs - extracellular enzymes – and influence of climate change	**15**	CO2, CO3	K2, K3
Module 3:	Factors affecting microbial ecology and diversity in specialized ecosystems – anthropogenic impacts - greenhouse gases - global warming, ocean acidification, deoxygenation - implications on biogeochemical processes. Mitigation measures. Analytical techniques in microbial ecology – productivity, biomass.	**15**	CO4, CO5	K2, K3
Pedagogy:	Lectures/assignments/field trip			
References/ Readings:	1. Dipper, F. and Tait, R.V. (1998). Elements of marine ecology, Butterworth-Heinemann, Oxford, U.K. 2. Gasol, J.M. and Kirchman, D.L. (2018). Microbial ecology of the oceans. Wiley- Blackwell Publishers, Oxford. 3. Munn, C.B. (2019). Marine microbiology: ecology and applications. CRC Press, Florida. 4. Nair, N.B. and Thampy, D.M. (1980). A textbook of marine ecology. Macmillan, Delhi.			

	5. Nybakken, J.W. and Bertness, M.D. (2004). Marine biology: an ecological approach. Benjamin- Cummings Pub Co., San Francisco. 6. Webber, H.H. and Thurman, H.V. (1984). Marine biology. HarperCollins Publishers, New York.

Title of the Course	Practical in Microbial Ecology
Course Code	MMI-5013
Number of Credits	1
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 provide hands-on training in microbial and biochemical techniques for assessing the abundance, productivity, and organic matter dynamics in marine environments.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Recall standard methods for estimating microbial biomass, productivity.	PSO1, PSO2
	CO 2. Describe the ecological significance of microbial activity and organic matter in marine biogeochemical processes.	PSO1, PSO2
	CO 3. Perform laboratory techniques to enumerate the effect of various physicochemical parameters on the growth and survival of microbes in seawater samples.	PSO1, PSO2
	CO 4. Assess variations in microbial and biochemical parameters to infer environmental conditions or ecosystem productivity.	PSO1, PSO2

Content:		No of hours	Mapped to CO	Cognitive Level
1	Estimation of bacterial biomass	**6**	CO 1	K2. K3, K4
2	Estimation of productivity using light and dark bottle technique	**8**	CO 1	K2. K3, K4
3	Experiments on the effect of various physicochemical parameters (salinity, pH, alkalinity, varying DOC concentration) on the growth and survival of selected marine bacterial isolates.	**16**	CO1, CO2, CO3, CO4	K2. K3, K4
Pedagogy:	Laboratory experiments and field studies			
References/ Readings:	1. Bratbak G. (1985). Bacterial biovolume and biomass estimations. Appl Environ Microbiol., 49(6):1488-93. 2. Cappuccino, J. G., & Sherman, N. (1998). Microbiology: A laboratory manual. California: Benjamin/Cummings Science Publishing. 3. Krishna M.S., Prasad V.R., Sarma V.V.S.S., Reddy N.P.C., Hemalatha K.P.J., and Y.V. (2015). Fluxes of dissolved organic carbon and nitrogen to the northern Indian Ocean from the Indian monsoonal rivers. Journal of Geophysical Research: Biogeosciences, 120:2067–2080. 4. Selvaraj, G. S. D. (2005). Estimation of primary productivity (modified light and dark bottle oxygen method). In: Mangrove ecosystems: A manual for the assessment of biodiversity. 83, CMFRI Special Publication			

Title of the Course	Analytical Techniques in Marine Microbiology
Course Code	MMI-5014
Number of Credits	3
Theory/Practical	T
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:	This course develops the concepts of methodology involved in studying the different aspects in microbiology and various techniques and instruments involved in metabolite analysis.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Describe the principle, working and applications of various techniques/instruments.	PSO1, PSO4
	CO 2. Identify the proper Biosafety levels of the work proposed.	PSO1, PSO3, PSO4
	CO 3. Apply the knowledge to utilise the appropriate technique/instrument for any analysis.	PSO1, PSO4
	CO 4. Interpret the technique/instrument necessary for metabolite analysis.	PSO1, PSO4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Chromatographic techniques: GC, HPLC, column/s matrix- Ion-exchange, affinity and molecular exclusion (using examples for separation of microbial lipids, pigments, nucleic acids and proteins/enzymes); Centrifugation: Principles, methodology, application; Density gradient centrifugation; Ultracentrifugation (Separation of ribosomal subunits of bacteria); Spectrophotometry: Atomic Absorption Spectrophotometry (AAS), UV-Visible, fluorimetry, Fourier transformation infra-red spectroscopy (FTIR), NMR, IRMS, ICP-MS, MALDI-TOF.	**15**	CO1, CO3, CO4	K3
Module 2:	Biohazards and Biosafety cabinet. Microscopy: Epifluorescence filter technique (DEFT), Electron microscopy, Phase contrast microscopy, Confocal microscopy; Radio-isotope and tracer techniques: Isotope and types of isotopes, Radio-activity counters, Autoradiography, Radiorespirometry; Cell and tissue culture techniques: Primary and secondary/established cell lines, Monolayer and suspension cultures, Fluorescence activated cell sorting (FACS).	**15**	CO1, CO2, CO3, CO4	K3
Module 3:	Electrophoretic techniques: PAGE, IEF, PFGE, DGGE, TGGE, Capillary electrophoresis, Single stranded conformation polymorphism (SSCP), Electroporator, Micro-array technique; Isolation of cell organelles: Different methods of cell lysis/ breakage and isolation and purification of various cell components - Cell surface structures, cell envelopes, plasma membranes, peptidoglycan, Outer membrane, ribosomes, protoplasts, spheroplast, DNA, RNA; X-ray diffraction, Oxygen analyser.	**15**	CO1, CO3, CO4	K3
Pedagogy:	Lectures/ assignments/ presentations/ research papers/ videos			
References/ Readings:	1. Colowick, S. P. and Kaplan, N. O. (1963). Methods in Enzymology, Vol. VI, Academic Press, N.Y. 2. Cooper, T. G. (2011). The Tools of Biochemistry, Wiley India Pvt. Ltd., Noida. 3. Goswami, C., Paintal, A. and Narain, R. (2011). Handbook of Bioinstrumentation, Wisdom Press, New Delhi. 4. Jayaraman, J. (2011). Laboratory Manual in Biochemistry, New Age International Publishers, New Delhi. 5. Norris, J. R. and Ribbons, D. W. (1971). Methods in Microbiology, Volume 5, Part B, Academic Press, N.Y. 6. Parakhia, M. V., Tomar, R. S., Patel, S. and Golakiya, B. A. (2010). Molecular Biology and Biotechnology:			

	Microbial Methods, NIPA New Delhi, Pitampura. 7. Wilson, K. and Walker, J. (2013). Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, N.Y., USA.

Title of the Course	Practical on Analytical Techniques in Marine Microbiology
Course Code	MMI-5015
Number of Credits	1
Theory/Practical	P
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:	This course develops the skills for techniques and instrumentation in microbiology.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Demonstrate microbial cells under the microscope.	PSO1, PSO2
	CO 2. Analyse separation of microbes based on their cell densities.	PSO1, PSO2
	CO 3. Employ cell disruption technique and UV-visible spectrophotometry for intracellular pigment profiling.	PSO1, PSO2
	CO 4. Analyze proteins using polyacrylamide gel electrophoresis.	PSO1, PSO2
	CO 5. Learn separation of biomolecules using molecular exclusion chromatography.	PSO1, PSO2

Content:		No of hours	Mapped to CO	Cognitive Level
1	Microscopy – compound, phase contrast – of bacterial, fungal cells.	**6**	CO 1	K5
2	Density gradient separation of mixed bacterial and/or yeast cells.	**6**	CO 2	K5
3	Cell disruption of pigmented bacteria/yeast by sonicator, efficacy of sonication and pigment profiling using UV-visible spectrophotometer.	**6**	CO 3	K5
4	Polyacrylamide gel electrophoresis (PAGE).	**6**	CO 4	K5
5	Molecular exclusion chromatography.	**6**	CO 5	K5
Pedagogy:	Experiments in the laboratory			
References/ Readings:	1. Cooper, T. G. (2011). The Tools of Biochemistry, Wiley India Pvt. Ltd., Noida. 2. Goswami, C., Paintal, A. and Narain, R. (2011). Handbook of Bioinstrumentation, Wisdom Press, New Delhi. 3. Jayaraman, J. (2011). Laboratory Manual in Biochemistry, New Age International Publishers, New Delhi. 4. Parakhia, M. V., Tomar, R. S., Patel, S. and Golakiya, B. A. (2010). Molecular Biology and Biotechnology: Microbial Methods, NIPA New Delhi, Pitampura. 5. Wilson, K. and Walker, J. (2013). Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, N.Y., USA.			

Discipline Specific Elective Coursess

Title of the Course	Marine Extremophilic Microorganisms
Course Code	MMI-5207
Number of Credits	3
Theory/Practical	T
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:	This course develops concepts relating to the ability of organisms to thrive in extreme marine ecosystems, their adaptations and biotechnological potential.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Identify and describe diverse types of extreme econiches in the marine environment.	PSO 1, PSO 2, PSO 5
	CO 2. Describe different types of extremophiles.	PSO 1, PSO 2, PSO 5
	CO 3. Critically evaluate the biotechnological potential of marine extremophilic microorganisms.	PSO 2, PSO 3
	CO 4. Describe the ecological significance of extremophilic microorganisms from the marine	PSO 1, PSO 2, PSO 5

	environment.			
	CO 5. Compare the adaptation strategies of different groups of extremophilic microorganisms from the marine environment.		PSO 1, PSO 2, PSO 5	
	CO 6. Discuss the application of extremophiles in astrobiology research and bioremediation.		PSO 1, PSO 2, PSO 5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Concept of extremophiles. Extreme marine econiche and their characteristics: marine trenches and ridges, submarine vents, cold seeps, deep sea basins and polar sea ice, glaciers, cryoconite holes, lakes, polynyas. Types of extremophiles (anaerobes, barophiles/piezophiles, cryophiles/psychrophiles, thermophiles and hyperthermophiles. oligotrophs, osmophiles, halophiles, xerophiles, alkaliphiles, acidophiles, radiophiles, metallophiles and xenobiotic utilizers).	**15**	CO1, CO2, CO3	K1, K2
Module 2:	Adaptation strategies, physiological features of anaerobes, barophiles/ piezophiles, cryophiles/psychrophiles, thermophiles and hyperthermophiles. oligotrophs, osmophiles, halophiles, xerophiles, alkaliphiles, acidophiles, radiophiles, metallophiles and xenobiotic utilizers.	**15**	CO4, CO5, CO6	K2, K3
Module 3:	Techniques used for isolation and characterization of diverse extremophilic groups: specialized equipment, media constituents, incubation conditions. application of selected extremophiles (thermophiles, psychrophiles, radiophiles, halophilic archaea) in astrobiology research. Biotechnological potential of extremophiles including in food, textile, and pharmaceutical industries. Application of extremophiles in bioremediation.	**15**	CO4, CO5, CO6	K2, K3
Pedagogy:	Lectures/ assignments/ videos.			
References/ Readings:	1. Brock, T. D. (2012). Thermophilic Microorganisms and Life at High Temperatures, Springer, New York. 2. Morita, R. Y. (1999). Extremophiles: Microbial life in extreme environments, Bioscience, 49(3), 245-248. 3. Rainey, F. A. & Oren, A. (2006). Extremophile microorganisms and the methods to handle them. Methods in Microbiology, 35, 1-25. 4. Satyanarayana, T., Raghukumar, C. & Shivaji, S. (2005). Extremophilic microbes: diversity and perspectives.			

	Current Science, 89(1), 78-90. 5. Ventosa, A., Nieto, J. J. & Oren, A. (1998). Biology of moderately halophilic aerobic bacteria. Microbiology and Molecular Biology Reviews, 62, 504-544.

Title of the Course	Practicals on Marine Extremophilic Microorganisms
Course Code	MMI-5208
Number of Credits	1
Theory/Practical	P
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:	This course aims to widen the students' understanding of the techniques involved in sampling extreme marine environments and processing and characterization procedures, for different categories of extremophiles.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the differences in culturing techniques for different groups of extremophiles.	PSO 1
	CO 2. Develop skills in isolation of different groups of extremophiles.	PSO 2
	CO 3. Design experiments to characterize different groups of extremophiles.	PSO 2, PSO 5
	CO 4. Evaluate the growth characteristics of microorganisms with respect to varying salt and nutrient concentrations.	PSO 2, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
1	Isolation of anaerobes (deep culture tubes/candle jar method/anaerobic jars).	**8**	CO1	K2, K3, K5
2	Techniques for isolation of xenobiotic-degraders and organic solvent-tolerant bacteria.	**7**	CO1, CO2	K2, K3, K5
3	Effect of varying salt concentrations on growth of halophiles/halotolerant microbes.	**8**	CO3, CO4	K2, K4, K5
4	Growth of bacterial isolates at varying nutrient concentrations (nitrate and phosphate).	**7**	CO3, CO4	K2, K4, K5
Pedagogy:	Experiments in the laboratory			
References/ Readings:	1. Kéki, Z., Grébner, K., Bohus, V., Márialigeti, K., & Tóth, E. (2013). Application of special oligotrophic media for cultivation of bacterial communities originated from ultrapure water. Acta Microbiologica et Immunologica Hungarica, 60(3), 345-357. 2. Rainey, F. A. & Oren, A. (2006). Extremophile microorganisms and the methods to handle them. Methods in Microbiology, 35, 1-25. 3. Russell, N. J. (2006). Antarctic micro-organisms: coming in from the cold. Culture, 27(2), e989. 4. Sardessai, Y. & Bhosle, S. (2002). Tolerance of bacteria to organic solvents. Research in Microbiology, 153, 263-268. 5. Uchino, Y. & Ken-Ichiro, S. (2011). A simple preparation of liquid media for the cultivation of strict anaerobes. Petroleum and Environmental Biotechnology, S3:001. doi:10.4172/2157-7463.S3-001. 6. Ventosa, A., Nieto, J. J. & Oren, A. (1998). Biology of moderately halophilic aerobic bacteria. Microbiology and Molecular Biology Reviews, 62, 504-544.			

Title of the Course	Marine Virology
Course Code	MMI-5209
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:	This course introduces the fundamental concepts of viruses in the marine environment. It covers diverse approaches used to study marine viruses, highlights their ecological roles and significance in marine ecosystems, and provides insights into select viral diseases affecting fish, shrimp, and shellfish.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Compare viruses from the marine environment infecting different hosts.	PSO 1, PSO 5
	CO 2. Understand and apply various instruments and techniques for characterizing marine bacteriophages and directly enumerating viruses in natural samples.	PSO 1, PSO 2
	CO 3. Evaluate the significance of viruses to the marine environment and global climate change.	PSO 1, PSO 5
	CO 4. Predict the effect of viral infection on different fish species.	PSO 1, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Virus Structure, Diversity and Assay: Marine Viruses – Introduction, nature, structure and classification (ICTV and Baltimore), New system of classsification; Marine phages and their host: Archaea, bacteria and cyanobacteria, phytoplankton, algae; Marine viruses and their hosts: fish and shrimp; Giant marine virus	**15**	CO1	K4
Module 2:	Significance of viruses in marine ecosystem: Viral shunt, Role in biogeochemical cycles, Movement of viruses between biomes; Effect of viruses on ecology of the marine ecosystem; Marine viruses and global climate change; Viral pathogens of fish and shellfish.	**15**	CO2	K2, K4
Module 3:	Techniques in marine virology: Multiplication and Assay of Phages and Viruses: Bacteriophage life cycles - lysogenic (latent) and lytic (virulent); Viral multiplication; One step growth profile; Assay: plaque assay (PA); most-probable number (MPN); epifluorescence microscopy, flow cytometry, transmission electron microscopy, Viral productivity, Metagenomic approaches to study the diversity of marine viruses	**15**	CO3, CO4	K3, K4
Pedagogy:	Lectures/ assignments/ Videos.			
References/ Readings:	1. Bosch, A., Le Guyader, S.F. (2010). Viruses in Shellfish and Food, Environmental Virology 2: 115-116. 2. Breitbart, M., Thompson, L. R., Suttle, C. A., Sullivan, M. B. (2007). Exploring the Vast Diversity of Marine Viruses. Oceanography, 20: 135-139. 3. Coutinho, F.H., Gregoracci, G.B., Walter, J.M., Thompson, C.C., and Thompson, F.L. (2018). Metagenomics sheds light on the ecology of marine microbes and their viruses, Trends in Microbiology, 26: 955-965. 4. Crane, M., Hyatt, A. (2011). Viruses of Fish: An Overview of Significant Pathogens. Viruses, 3: 2025–2046. 5. Danovaro, R., Corinaldesi, C., Dell'Anno, A., Fuhrman, J.A., Middelburg, J.J., Noble, R.T., Suttle, C.A. (2011). Marine viruses and global climate change. FEMS Microbiology Reviews, 35: 993–1034. 6. Davis, B. D., Dulbecco, R., Eisen, H. N. and Ginsberg, H. S. (1982). Microbiology, Harper and Row Publishers, N.Y. 7. Rohwer, F., Thurber, R. V. (2009). Viruses manipulate the marine environment. Nature, 459: 207-212.			

	8. Sano, E., Carlson, S., Wegley, L., Rohwer, F. (2004). Movement of Viruses between Biomes**.** Applied and Environmental Microbiology, 70: 5842–5846. 9. Woo, P. T. K. and Bruno, D. W. (2011). Fish Diseases and Disorders. Vol 3: Viral, Bacterial and Fungal Infections. CABI Publishing, England.
Web Resources:	https://www.youtube.com/watch?v=2RFtYd_gQnU&t=978s https://www.youtube.com/watch?v=PEDUw3I00Yg

Title of the Course	Practical in Marine Virology
Course Code	MMI-5210
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	Yes

Pre-requisites for the Course:	Nil			
Course Objectives:	This course develops the skills for handling bacterial viruses.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Demonstrate working with marine samples for the isolation of bacteriophages.		PSO 2	
	CO 2. Discuss various techniques for bacteriophage characterization.		PSO 2	
	CO 3. Identify the phases of the phage growth curve.		PSO 2	
	CO 4. Design the work plan for bacteriophage work from an environmental sample.		PSO 2, PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
1	Isolation of marine bacteriophages by double agar layer method.	**3**	CO1, CO4	K5, K6

2	Purification of bacteriophages.	**3**	CO2, CO4	K5, K6
3	Phage growth curve and titration of phage lysate and determination of MOI, latent period, burst size (Phage assay)	**12**	CO3, CO4	K3, K4, K5, K6
4	Optimization of various growth factors for improving the phage titer.	**12**	CO3, CO4	K3, K4, K5, K6
Pedagogy:	Experiments in the laboratory			
References/ Readings:	1. Burleson, F.G., Chambers, T.M. and Wiedbrauk, D.L. (2014). Virology: A Laboratory Manual, Elsevier, Netherlands. 2. Goldstein, G., Wm. C. (1992). Introductory Experiments in Virology, Brown & Benchmark Publishers, Ohio. 3. Mahy, B.W.J. and Kangro, H.O. (1996). Virology Methods Manual, Academic Press, N.Y. 4. Wilson, K. and Walker, J. (2013). Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, N.Y., USA.			

Title of the Course	Archaea
Course Code	MMI-5211
Number of Credits	3
Theory/Practical	T
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:	This course develops concept of three domains of life, ecology, physiology, diversity, cell structure, metabolism, energetics and genetics of archaea.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Classify and summarize the types of archaea.		PSO1	
	CO 2. Describe the ecological niches and culturability		PSO1	
	CO 3. Draw the biochemical pathways and calculate its energetics		PSO1, PSO2	
	CO 4. Understand the genetic makeup of archaea and emphasize its uniqueness		PSO1	
	CO 5. Explain the gene organisation and compare the operons in archaea		PSO1, PSO2	
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	Carl Woese's three domain classification of life, classification of archaea. Cellular organization of archaea. Ecology, physiology and diversity of Archaea. Nutrition, growth and growth kinetics and physiological versatility. Stress response of methanogenic, halophilic, thermophilic, thermoacidophilic, barophilic, alkaliphilic and psychrophilic archaea. Methanotrophs, methylotrophs. Global econiches: deep sea, hydrothermal vents, Dead Sea, solar salterns, geothermal vents, solfataras, Antarctica, soda lake. Study of archaeal diversity. Unculturable archaeal studies by metagenomics. Archaeal culture retrieval methods. Novel samplers. Preservation and maintenance of archaeal cultures. Significance of Archaea: biogeochemical cycling, biotechnology.	**15**	CO1, CO2	K1, K2
Module 2:	Metabolism and energetics of Archaea: modified anabolic pathways of carbohydrates and lipids, methanogenesis and acetoclastic reactions. Modified central metabolic pathways – EMP, ED, incomplete TCA, reverse Kreb cycle, carbon dioxide reduction pathways – reductive acetyl-CoA pathway, 3-hydroxypropionate pathway. Chemolithoautotrophy. Bioenergetics – ATP synthesis (i) respiration-driven; (ii) light-driven, involving bacteriorhodopsin; and (iii) chloride-driven, involving halorhodopsin.	**15**	CO3	K1-K3
Module 3:	Genome of Archaea: size of genome, G + C content, associated proteins, archaeal histones and nucleosomes, introns in archaea. Archaeal RNA polymerases, reverse DNA gyrase. Plasmids, transposons -IS elements. Modifications in tRNA and rRNA structure. Novel 7S rRNA. DNA replication, transcription and translation in archaea. Gene organization in Archaea: (i) *his* operon; (ii) *bob* operon; and (iii) *mcr* operon.	**15**	CO4, CO5	K1-K3
Pedagogy:	Lectures/assignments.			
References/ Readings:	1. Boone, D. R., & Castenholz, R. W. (1984). Bergey's manual of systematic bacteriology. Vol. I, The Archaea and the deeply branching and phototrophic bacteria. Springer. 2. Cavicchioli, R. (2007). Archaea**:** Molecular and cellular biology. ASM Press. 3. Corcelli, A., & Lobasso, S. (2006). Characterization of Lipids of Halophilic Archaea. Methods in Microbiology. 35, 585-613.			

	4. Garrett, R. A., & Hans-Peter, K. (2007). Archaea: Evolution, physiology and molecular biology. John Wiley and Sons. 5. Munn, C. (2004). Marine microbiology: Ecology and applications. Garland Science, Taylor and Francis Group. 6. Rothe, O., & Thomm, M. (2000). A simplified method for the cultivation of extreme anaerobic archaea based on the use of sodium sulfite as reducing agent. Extremophiles. 4, 247-252. 7. Woese, C. R., & Fox, G. E. (1977). Phylogenetic structure of the prokaryotic domain: the primary kingdoms. Proceedings of the National Academy of Sciences USA. 74, 5088–5090.

Title of the Course	Practical on Archaea
Course Code	MMI-5212
Number of Credits	1
Theory/Practical	P
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:	This course focuses on sampling, isolation and identification techniques of archaea from different econiches and the study of archaeal pigments.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Analyse samples from different econiches for archaea		PSO 1, PSO 2	
	CO 2. Perform isolation, culturing and identification of archaea.		PSO 1, PSO 2	
	CO 3. Carry out bioprospecting of bioactive molecules from archaea.		PSO 4	
	CO 4. Assess the archeal isolates for industrially important enzymes		PSO 4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

1	Isolation and culturing of archaea	6	CO 1	K4, K5
2	Identification of archaeal isolates	6	CO 2	K3-K6
3	Biochemical tests for archaea.	6	CO 2	K4, K5
4	Extraction of archaeal pigment and characterization using UV-Vis spectroscopy.	6	CO 3	K4, K5
5	Screening for archaeal enzymes.	6	CO3, CO4	K4, K5
Pedagogy:	Experiments in the laboratory			
References/ Readings:	1. Boone, D. R., & Castenholz, R. W. (1984). Bergey's manual of systematic bacteriology. Vol. I, The Archaea and the deeply branching and phototrophic bacteria. Springer. 2. Kumar, S., Karan, R., Kapoor, S., et al. (2012). Screening and isolation of halophilic bacteria producing industrially important enzymes. Brazilian Journal of Microbiology. 43(4),1595-603. doi: 10.1590/S1517-838220120004000044. 3. Rothe, O., & Thomm, M. (2000). A simplified method for the cultivation of extreme anaerobic archaea based on the use of sodium sulfite as reducing agent. Extremophiles. 4, 247-252.			

Title of the Course	Microbial Physiology and Interactions
Course Code	MMI-5213
Number of Credits	3
Theory/Practical	T
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:	This course aims to deepen students' understanding of the diverse protist groups in the marine environment, and focuses on the diverse physiological and nutritional strategies of microorganisms, and their interactions within and across trophic levels.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Describe the diverse protists and their features in the marine environment.	PSO 1, PSO 5
	CO 2. Describe the physiological and nutritional characteristics of marine microorganisms.	PSO 1, PSO 5
	CO 3. Summarize the interactions of marine microorganisms within and across trophic levels.	PSO 2, PSO 5
	CO 4. Analyze the role and significance of quorum sensing in communication within and across trophic levels.	PSO 2, PSO 5

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Characteristics of protists: eukaryotic cell surfaces and organelles, organs of locomotion (cilia and flagella), chemotaxis; diverse protists in the marine environment: euglenids, bicosoecids, choanoflagellates, dinoflagellates, ciliates, haptophytes, diatoms, raphidophytes, stramenopiles, thraustochytrids, labrinthulids, amoebozoa, radiolarians, foraminifera; multiple marine protistan lineages in seven supergroups of the eukaryotic tree of life.	**15**	CO 1	K1, K2
Module 2:	Physiology and nutrition of marine microorganisms. Structure and organization of membranes: bilayer model, Danielli-Davson's trilaminar sandwich model, Robertson's unit membrane model, Singer and Nicholson's fluid mosaic model; protein diffusion, osmosis, fluidity and permeability of membranes; transport and translocation of metabolites and proteins across membranes: facilitated diffusion; active transport (primary active transport, ABC Transporters; and secondary active transport, chemiosmotic-driven transport); vesicular transport (endocytosis and exocytosis); mechanosensitive channels, ATP-linked ion motive pumps; siderophores and iron transport; osmotic stress and osmoregulation; osmotic control of gene regulation. Metabolic diversity: Phototrophy, chemotrophy, thiotrophy, autotrophy, mixotrophy, heterotrophy; acquired phototrophy; photosynthesis, anaerobic anoxygenic photosynthesis, aerobic anoxygenic phototrophy.	**15**	CO 2	K1, K2
Module 3:	Microbial interactions. The paradox of the plankton; interactions within and across trophic levels (allelopathic interactions); chemical ecology; signalling molecules, quorum sensing, types of autoinducers (Acyl Homoserine Lactone molecules, peptides, pheromones); quorum sensing in biofilms; bioluminescence; quorum quenching; intra-species, inter-species and cross-kingdom interactions in marine ecosystems; host-symbiont interactions (microbe-sponge interactions); indirect chemical defence of microalgae (nitric oxide, lipids).	**15**	CO 3, CO 4	K2, K3, K4
Pedagogy:	Lectures/ assignments/ videos.			

References/ Readings:	1. Bassler, B.L., & Winnans, S.C. (2008). Chemical Communication Among Bacteria. ASM Press, United Kingdom. 2. Caldwell, D. R. (1995). Microbial Physiology & Metabolism. Wm. C. Brown, Germany. 3. Moat, A. G., & Foster, J. W., & Spector, M. P. (2002). Microbial Physiology. Microbial Physiology, 4th Edn. Wiley-Liss Inc., New York. 4. Munn, C. (2011). Marine Microbiology: Ecology and Applications, Garland Science, Taylor and Francis Group, New York. 5. Wiley J.M., Sherwood L.M. & Woolverton C.J. (2019). Prescott's Microbiology. 11th Edition. McGraw Hill International.

Title of the Course	Coral Ecosystem and Associated Microbiota
Course Code	MMI-5214
Number of Credits	3
Theory/Practical	T
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:	This course focuses on the various characteristics of coral ecosystems including the physico-chemical variables, evolution, survival strategies and associated microbial diversity.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the biodiversity of corals and their interactions.	PSO1
	CO 2. Describe coral ecosystem function and examine its economic implications.	PSO2, PSO3
	CO 3. Indicate the physico-chemical and biological factors influencing coral ecology.	PSO1
	CO 4. Create awareness of the impact of anthropogenic activities on coral health.	PSO5
	CO 5. Identify microbial infections in corals and understand their epidemiology.	PSO4

	CO 6. Survey the conservation and management strategies of damaged corals and their recovery.		PSO4, PSO5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Introduction to Corals: Coral reef biology - Types of corals, composition, ecology, structure- anatomy and physiology. Types of coral reefs and their global distribution. Factors affecting coral reefs – Abiotic factors: pH, temperature, salinity, sedimentation, wave action, weather conditions, nutrient availability, pollution, aerial exposure, light. Biological factors: competitors, disease, predators, symbiotic relationships, nutrient flux. Natural and human disturbances to reefs and their impacts. Influence of microbes on coral health. Importance of coral reefs - Fisheries and marine products associated with coral reefs. Ecological importance of coral reefs. Cultivation and conservation of corals. Law and policy for conservation and management of corals in India, permissions for coral sample collection.	**15**	CO 1, CO 2	K1, K2
Module 2:	Microbial interaction with coral communities: Coral microbial communities and trophic structure. Microbes, Primary producers, consumers, food webs, productivity in coral reefs. Coral and microbiome dynamics – Coral holobiont. Rosenberg's hologenome hypothesis, Adaptive bleaching hypothesis (ABH), Adaptive Dysbiosis hypothesis (ADH), Coral probiotic hypothesis, DDAMed Model, Influence of sponge loop on corals. Symbiotic associations: Algal-coral associations, bacterial symbiosis, Multi-partner symbiosis. Nutrient cycling.	**15**	CO 3, CO 4	K2, K3
Module 3:	Diagnosis and recovery of diseased/damaged corals: Microbial causative agents associated with coral diseases – Bacterial, fungal, viral and proteozoic infections disease spread assessment, treatment and recovery - Coral disease survey and monitoring protocols. Disease response plan. Outbreak management. Use of antibiotics and antioxidants for treating diseased corals. Phage therapy. Coral Restoration strategies carried out by national and international groups.	**15**	CO 5, CO 6	K5, K6
Pedagogy:	Lectures/ assignments/ videos.			
References/	1. Chakravarti L. J., Van Oppen M. J. H. (2018). Experimental Evolution in Coral Photosymbionts as a Tool to			

Readings:	Increase Thermal Tolerance. Frontiers in Marine Science. 5 :227. 2. Contardi M. et al. (2020) Treatment of coral Wounds by combining an Antiseptic Bilayer film and an injectable Antioxidant Biopolymer. Scientific Reports.10: 988. 3. Munn C.B. (2019). Marine Microbiology: Ecology and Applications, CRC Press. Florida. 3. Jones O.A. & Endean R. (1973). Biology and Geology of coral reefs (1st edn). Academic Press. Cambridge. 4. Sheppard C., Davy S., Pilling G. & Graham N. (2018). The Biology of Coral Reefs (2nd edn). Oxford University Press. USA. 5. Van Oppen M. J. H. & Blackal L. L. (2019). Coral microbiome dynamics, functions and design in a changing world. Nature Reviews Microbiology. 17: 557–567. 6. Van Oppen M. J. H. et al. (2015). Building coral reef resilience through assisted evolution. PNAS. 112 (8): 2307-2313.

Title of the Course	Fieldtrip
Course Code	MMI-5215
Number of Credits	1
Theory/Practical	P
Level	400
Effective from AY	2025-26
New Course	No
Value added Course	Yes
Course for advanced learners	Yes

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide knowledge about the on-going research in various national research institutes, and the functioning of microbiology related industries and industrial processes. To provide hands-on experience in collection of water and sediment samples from the marine environment.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Discover and examine the working of microbiology-related industries.	PSO1
	CO 2. Appraise on ongoing/recent research activities carried out in the fields of marine microbiology and oceanography.	PSO1, PSO2
	CO 3. Formulate work plans for the collection of water and sediment samples from the marine environment.	PSO2
	CO 4. Effectively communicate observations, findings, and analyses from the field trip through	PSO4

	a well-organized report.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
1	Visit to national research institutes.	**30**	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
2	Visit to industries.			
3	Sampling in the marine environment using water samplers and sediment grabs.			
4	Report writing based on the visits.			
5	Presentation and group discussion based on the visits.			
Pedagogy:	Visits to research institutes and industries. Demonstration of equipment available with respective laboratories, interaction with personnel working in the field of microbiology in the respective institutes. Field trip visits to estuarine environments aboard a trawler for the collection of water and sediment samples.			
References/ Readings:	As suggested by the supervisor to the participating students.			