

# गोंय विद्यापीठ

ताळगांव पठार,

गोंय - ४०३ २०६

फोन : +९१-८६६९६०९०४८



## Goa University

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(Accredited by NAAC)

GU/Acad -PG/BoS -NEP/2025-26/175

Date: 26.06.2025

### 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 Microbiology** Programme approved by the Academic Council in its meeting held on 13<sup>th</sup> & 14<sup>th</sup> June 2025 is attached.

The Dean & Vice-Dean (Academic) of the School of Biological Sciences and Biotechnology and the Principals of the Affiliated Colleges offering the **Master of Science in Microbiology** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

(Ashwin V. Lawande)  
Deputy Registrar – Academic

To,

1. The Dean, School of Biological Sciences and Biotechnology, Goa University.
2. The Vice-Dean (Academic), School of Biological Sciences and Biotechnology, Goa University.
3. The Principals of Affiliated Colleges offering the Master of Science in Microbiology Programme.

Copy to:

1. Chairperson, BoS in Microbiology, Goa University.
2. Programme Director, M.Sc. 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 (M.Sc.) IN MICROBIOLOGY

(Effective from the Academic Year 2025-2026)

### ABOUT THE PROGRAMME

The Programme is meant for students of B.Sc. (Microbiology) to pursue higher studies in Microbiology. It serves to impart advanced training to the students in the field of Microbiology with focus on microbial diversity, bioprospecting and applications of microbes for obtaining 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 Programme 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.

### OBJECTIVES OF THE PROGRAMME

The objectives of M.Sc. Microbiology are:

- Provide students with knowledge, practical abilities and skills in microbiology required to work in the industry, institutions, national and international organisations.
- Imparting abilities for solving problems in society and industries using microbiological solutions leading to entrepreneurship and sustainable goals.
- Develop confident, adaptable and competent individuals for an evolving society through their professional expertise and personal abilities.

### Exit Option

Student can opt for Exit option after completion of Semester 1 and 2 with completion of internship. The student will be awarded “PG Diploma in Microbiology”

<b>PROGRAMME SPECIFIC OUTCOMES (PSO)</b>	
<b>PSO 1.</b>	Understanding the concepts of microbiology along with the distribution, morphology, physiology, and genetics of microorganisms.
<b>PSO 2.</b>	Learning about the roles and application of microorganisms in diverse fields.
<b>PSO 3.</b>	Demonstrating skills in aseptic handling of microorganisms and their processes.
<b>PSO 4.</b>	Analysing and evaluate data using tools and methodologies essential for microbiological experimentation, enhancing practical competencies and research capabilities for scientific inquiry, application and technological innovation.
<b>PSO 5.</b>	Create and design laboratory techniques, research methodologies, and microbiological tools essential for biological experimentation and innovation.
<b>PSO 6.</b>	Applying good laboratory and manufacturing practices in microbial processes and products in industries.
<b>PSO 7.</b>	Identifying ethical issues related to intellectual property rights, biosafety, and biohazards.
<b>PSO 8.</b>	Competence in identifying real-world problems and finding innovative solutions by microbiological research leading to entrepreneurship, employment and achieving sustainable goals.



## PROGRAMME STRUCTURE

### M.Sc. in Microbiology effective from Academic Year 2025-26

<b>SEMESTER I</b>				
<b>Discipline Specific Core (DSC) Courses (16 credits)</b>				
Sr. No.	Course Code	Title of the Course	Credits	Level
1	MIC-5000	Microbial Biochemistry [T]	3	400
2	MIC-5001	Microbial Biochemistry [P]	1	400
3	MIC-5002	Microbial Genetics [T]	3	400
4	MIC-5003	Microbial Genetics [P]	1	400
5	MIC-5004	Techniques and Instrumentation in Microbiology [T]	3	400
6	MIC-5005	Techniques and Instrumentation in Microbiology [P]	1	400
7	MIC-5006	Biostatistics [T]	3	400
8	MIC-5007	Biostatistics [P]	1	400
<b>Total Credits for DSC Courses in Semester I</b>			<b>16</b>	
<b>Discipline Specific Elective (DSE) Course (4 credits)</b>				
Sr. No.	Course Code	Title of the Course	Credits	Level
1	MIC-5201	Environmental Microbiology and Bioremediation [T]	3	400
2	MIC-5202	Environmental Microbiology and Bioremediation [P]	1	400
3	MIC-5203	Immunology [T]	3	400
4	MIC-5204	Immunology [P]	1	400
<b>Total Credits for DSE Courses in Semester I</b>			<b>4</b>	
<b>Total Credits in Semester I</b>			<b>20</b>	

Note:

- Student who is opting MIC-5201 has to also take MIC-5202.
- Student who is opting MIC-5203 has to also take MIC-5204.

<b>Semester II</b>				
<b>Discipline Specific Core (DSC) Courses</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
1	MIC-5008	Microbial Taxonomy and Systematics [T]	3	500
2	MIC-5009	Microbial Taxonomy and Systematics [P]	1	500
3	MIC-5010	Industrial Microbiology [T]	3	500
4	MIC-5011	Industrial Microbiology [P]	1	500
5	MIC-5012	Molecular Biology [T]	3	500
6	MIC-5013	Molecular Biology [P]	1	500
7	MIC-5014	Archaea – Ecology, Physiology, Biochemistry, and Genetics [T]	3	500
8	MIC-5015	Archaea – Ecology, Physiology, Biochemistry, and Genetics [P]	1	500
<b>Total Credits for DSC Courses in Semester II</b>			<b>16</b>	
<b>Discipline Specific Elective (DSE) Courses (4 credits)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
1	MIC-5205	Agriculture Microbiology [T]	3	400
2	MIC-5206	Agriculture Microbiology [P]	1	400
3	MIC-5207	Mycology [T]	3	400
4	MIC-5208	Mycology [P]	1	400
5	MIC-5209	Internship	4	400
<b>Total Credits for DSE Courses in Semester II</b>			<b>4</b>	
<b>Total Credits in Semester II</b>			<b>20</b>	

Note:

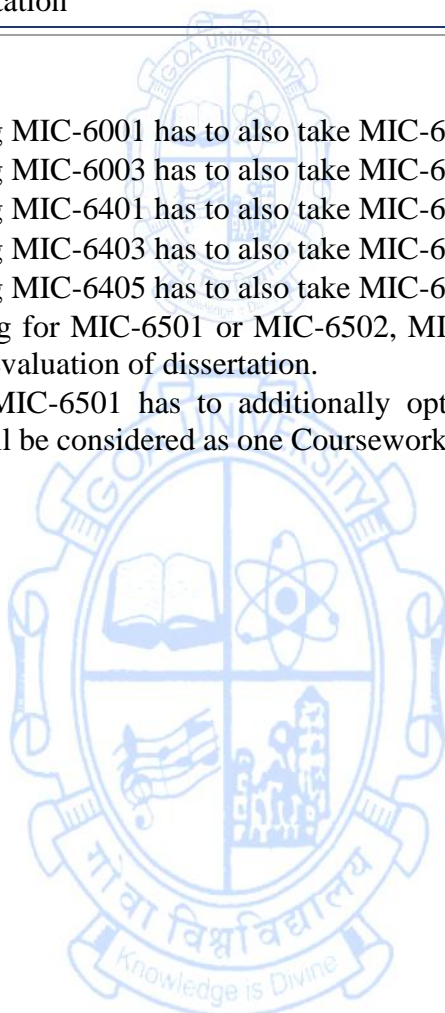
- Student who is opting MIC-5205 has to also take MIC-5206.
- Student who is opting MIC-5207 has to also take MIC-5208.
- Student who is opting MIC-5209 make note that the credits obtained for this course will not be counted for the award of M.Sc. in Microbiology OR PG Diploma in Microbiology.
- For PG Diploma in Microbiology MIC-5209 is an essential Exit Course.

<b>Semester III</b>				
<b>Research Specific Elective (RSE) Courses (12 credits)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
1	MIC-6000	Research Methodology and Advanced Biostatistics	4	500
2	MIC-6001	Microbial Technology [T]	3	500
3	MIC-6002	Microbial Technology [P]	1	500
4	MIC-6003	Extremophilic Microorganisms [T]	3	500
5	MIC-6004	Extremophilic Microorganisms [P]	1	500
6	MIC-6005	Aquatic Virology [T]	2	500
7	MIC-6006	Bioinformatics [T]	2	500
8	MIC-6007	Python for Biologists [T]	2	500
9	MIC-6008	Field Trip to industries/institutions [P]	2	500
10	MIC-6009	Field Trip to coastal ecosystems and allied industries [P]	2	500
<b>Total Credits for RSE Courses in Semester III</b>			<b>12</b>	
<b>Discipline Specific Vocational Elective (DSVE) Courses (8 credits)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
1	MIC-6401	Pharmaceutical Microbiology [T]	2	500
2	MIC-6402	Pharmaceutical Microbiology [P]	2	500
3	MIC-6403	Food Microbiology [T]	2	500
4	MIC-6404	Food Microbiology [P]	2	500
5	MIC-6405	Marine Microbiology [T]	2	500
6	MIC-6406	Marine Microbiology [P]	2	500
<b>Total Credits for DSVE Courses in Semester III</b>			<b>8</b>	
<b>Total Credits in Semester III</b>			<b>20</b>	

<b>Discipline Specific Dissertation (DSD) (40 Credit Dissertation)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
<b>1</b>	<b>MIC-6501</b>	<b>Dissertation</b>	<b>40</b>	<b>500</b>

Note:

- Student who is opting MIC-6001 has to also take MIC-6002.
- Student who is opting MIC-6003 has to also take MIC-6004.
- Student who is opting MIC-6401 has to also take MIC-6402.
- Student who is opting MIC-6403 has to also take MIC-6404.
- Student who is opting MIC-6405 has to also take MIC-6406.
- Student who is opting for MIC-6501 or MIC-6502, MIC-6000 will be considered as one Coursework for evaluation of dissertation.
- Student opting for MIC-6501 has to additionally opt for another coursework for Semester III. That will be considered as one Coursework for evaluation of dissertation.



<b>Semester IV</b>				
<b>Generic Elective (GE) Courses (20 credits)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
1	MIC-6201	Microbial Bioprospecting [T]	4	500
2	MIC-6202	Genetic Engineering [T]	3	500
3	MIC-6203	Genetic Engineering [P]	1	500
4	MIC-6204	Medical Microbiology and Epidemiology [T]	3	500
5	MIC-6205	Medical Microbiology and Epidemiology [P]	1	500
6	MIC-6206	Marine Microbial Interactions [T]	3	500
7	MIC-6207	Marine Microbial Interactions [P]	1	500
8	MIC-6208	Medical Virology [T]	3	500
9	MIC-6209	Medical Virology [P]	1	500
10	MIC-6210	Entrepreneurship in Microbiology	4	500
11	MIC-6211	Microbiology of Fish and Fish Product	4	500
<b>IV</b>	<b>Total Credits for GE Courses in Semester</b>			<b>20</b>

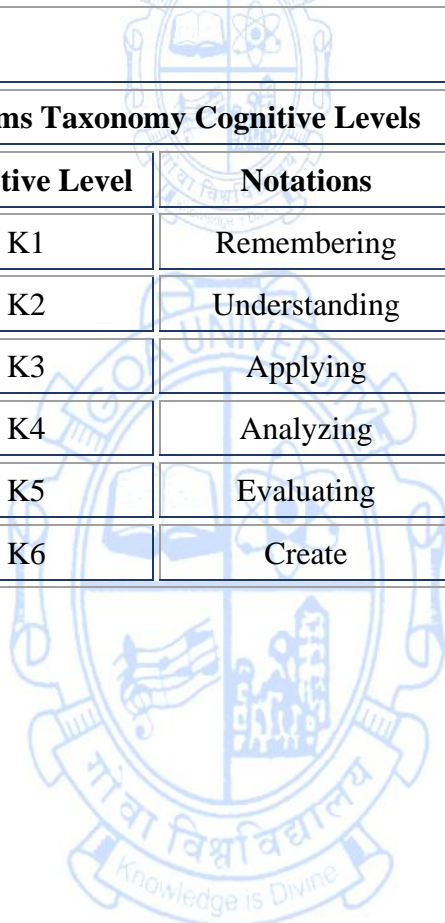
Note:

- Student who is opting MIC-6202 has to also take MIC-6203.
- Student who is opting MIC-6204 has to also take MIC-6205.
- Student who is opting MIC-6206 has to also take MIC-6207.
- Student who is opting MIC-6408 has to also take MIC-6409.

<b>Generic Elective (GE) Online Courses (Maximum 8 Credits)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
13		Course will be identified by BoS as and when required		500
<b>Total Credits for GE Online Courses in Semester IV</b>			<b>8</b>	

<b>Discipline Specific Dissertation (DSD) (20 Credit Dissertation)</b>				
<b>Sr. No.</b>	<b>Course Code</b>	<b>Title of the Course</b>	<b>Credits</b>	<b>Level</b>
<b>1</b>	<b>MIC-6502</b>	<b>Dissertation</b>	<b>20</b>	<b>500</b>
<b>Total Credits in Semester IV</b>			<b>20</b>	

<b>Blooms Taxonomy Cognitive Levels</b>	
<b>Cognitive Level</b>	<b>Notations</b>
K1	Remembering
K2	Understanding
K3	Applying
K4	Analyzing
K5	Evaluating
K6	Create



## SEMESTER I

### Discipline Specific Core Courses

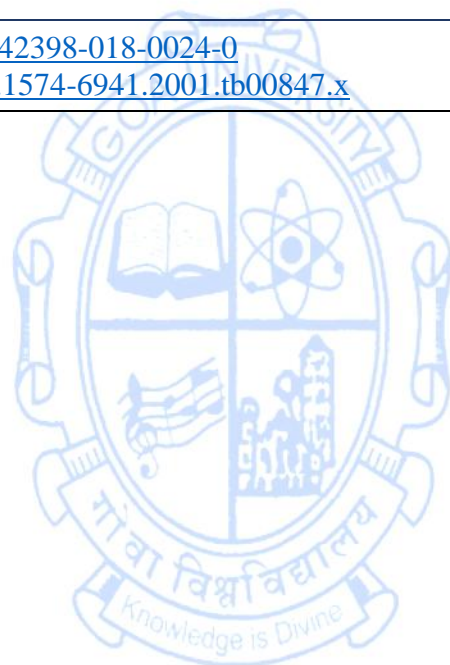
<b>Title of the Course</b>	Microbial Biochemistry [T]	
<b>Course Code</b>	MIC-5000	
<b>Number of Credits</b>	03	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	This course deals with the characteristics, properties and biological significance of the biomolecules of life. In depth knowledge of the energetics and regulation of different metabolic processes in microorganisms.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Apply the principles of biochemical processes to microbial physiology	PSO1, PSO2, PSO3, PSO4, PSO5

	CO 2. Demonstrate the regulation of the biochemical pathway		PSO1, PSO2, PSO3, PSO4	
	CO 3. Discriminate metabolic processes applicable to various biomolecules of the microbial origin		PSO2, PSO3, PSO4, PSO5	
	CO 4. Explore microorganisms for their microbial products		PSO1, PSO2, PSO4, PSO7, PSO8	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>	
<b>Module 1:</b>	<b>Biological Molecules</b>	<b>08</b>	CO1, CO2, CO3	K1, K2, K3
	1.1 Protein			
	Amino acids: features and properties. Protein: structure, principles of separation and purification, molecular weight determination; sequencing and chemical synthesis. Enzymes: activity, inhibition, mechanism of action; regulatory – allosteric and covalently modulated enzymes and their significance in metabolism			
	1.2 Carbohydrate	<b>04</b>	CO1, CO2, CO3	K1, K2, K3
	Monosaccharides: types, characteristics and properties. Disaccharides, oligosaccharides, polysaccharides – Biological significance.			
	1.3 Lipid	<b>03</b>	CO1, CO2, CO3	K1, K2, K3
Fatty acids: saturated and unsaturated, structure and properties. Lipids: classification, structure (phospholipids, sphingolipids), properties; biological significance; lipid composition of microorganisms.				
<b>Module 2:</b>	<b>Bioenergetics and Carbohydrate Metabolism</b>	<b>03</b>	CO1	K2, K4
	2.1 Bioenergetics			

	Thermodynamics, exergonic and endergonic reactions, redox potential, high energy compounds, ATP structure and significance.			
	2.2 Oxidative Phosphorylation	03	CO1, CO3	K2, K3, K4
	Redox enzymes, aerobic electron transport and oxidative phosphorylation, Proton Motive Force			
	2.3 Carbohydrate metabolism	09	CO1, CO2, CO3	K2, K3, K4, K5
	Carbohydrates: Central pathways of metabolism – regulatory mechanisms, bioenergetics and significance – EMP, TCA cycle (glucose aerobic and anaerobic metabolism, malate metabolism), Homolactic and Heterolactic acids pathway, Glyoxylate cycle. Utilization of sugars such as lactose, galactose, maltose and of polysaccharides such as starch, glycogen, cellulose, pectin. Gluconeogenesis from TCA intermediates / amino acids / acetyl-CoA; biosynthesis of polysaccharides (Peptidoglycan, starch and glycogen) and sugar inter-conversions.			
<b>Module 3:</b>	<b>Lipids, Amino Acids, Nucleotides and other Metabolic Paths</b>	04	CO1, CO2, CO3	K2, K3, K4
	3.1 Lipid Metabolism			
	Catabolism: Oxidation of fatty acids and the bioenergetics involved. Anabolism: Biosynthesis of fatty acids: saturated and unsaturated, triglycerides, phospholipids, sterol.			
	3.2 Amino Acid and Nucleotide Biosynthesis	04	CO1, CO2, CO3	K2, K3, K4
	Amino acid biosynthetic pathways and their regulation. Purine and pyrimidine nucleotides, Deoxyribo nucleotides: biosynthesis and regulation. Biosynthesis of nucleotide coenzymes.			
	3.3 Photosynthetic Metabolism	03	CO1, CO2,	K2, K3, K4 K5, K6
Microorganisms and photosynthetic pigments, fundamental processes in Photosynthesis.				

	Photosynthetic electron transport; Oxygenic and anoxygenic Photosynthesis; photophosphorylation.		CO3, CO4	
	3.4 Chemolithotrophic microorganisms	02	CO1, CO2, CO3, CO4	K2, K3, K5, K6
	Pathways, bioenergetics and significance			
	3.5 Antimetabolites of Microbial Origin	02	CO1, CO2, CO3, CO4	K2, K3, K5, K6
	Structure, biosynthesis, types and mechanism of action			
<b>Pedagogy:</b>	<b>Lectures/tutorials/assignments/Group Discussion/Seminar/ICT tools</b>			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Berg, J.M., Tymoczko, J.L., Gatto, G.J. and Stryer, L. (2019) Biochemistry. Ninth Edition, W. H. Freeman &amp; Company, USA.</li> <li>2. Bull, A. T. and Meadow, P., (1978) Companion to Microbiology, First Edition, Longman Group Limited, New York.</li> <li>3. Devasena T., (2010) Enzymology, Third edition, Oxford university Press , India</li> <li>4. Jayaraman, J., (1981) Laboratory Manual in Biochemistry, Second edition, John Wiley &amp; Sons, Limited, Australia.</li> <li>5. Lehninger, A., Cox, M. and Nelson, D. L., (2021) Principles of Biochemistry, Eighth Edition, W. H. Freeman &amp; Company, USA.</li> <li>6. Moat, A. G., Foster, J. W. and Spector, M. P., (2003) Microbial Physiology, Fourth Edition, A. John Wiley &amp; Sons Inc. Publication, New York.</li> <li>7. Murray, R. K., Bender, D. A., Botham, K. M., Kennelly, P. J., Rodwell, V. W. and Weil, P. A., (2023) Harper's Illustrated Biochemistry, Thirty second Edition, The McGraw-Hill LLC., USA.</li> <li>8. Plummer, D. T., (2001) An Introduction to Practical Biochemistry, Tata McGraw Hill Publishing Company, New York.</li> <li>9. Sadasivam, S., Manickam, A., (2007) Biochemical Methods, Fourth Edition, New Age International (P) Limited, New Delhi</li> <li>10. Voet, D., Voet, J. G. and Pratt, C. W., (2018) Principles of Biochemistry, Fifth edition, John Wiley and Sons Inc, USA.</li> </ol>			

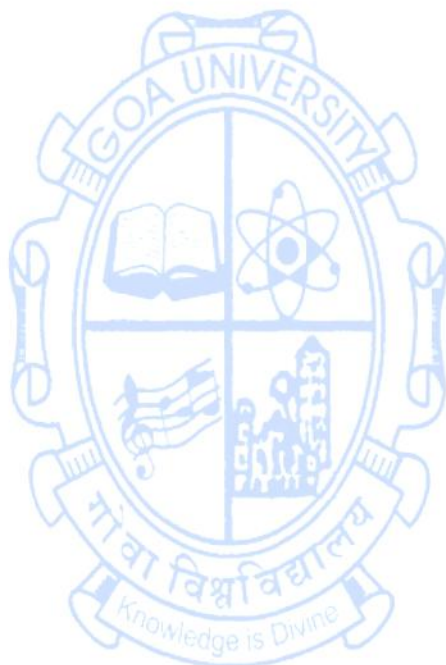
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Borgia, J. A., &amp; Fields, G. B. (2000). Chemical synthesis of proteins. <i>Trends in biotechnology</i>, 18(6), 243-251.</li> <li>2. Chaudhary, S., Tanvi, R. D., &amp; Goyal, S. (2019). Different applications of sulphur oxidizing bacteria: A review. <i>Int. J. Curr. Microbiol. App. Sci</i>, 8(11), 770-778.</li> <li>3. Harel, O., &amp; Jbara, M. (2023). Chemical synthesis of bioactive proteins. <i>Angewandte Chemie</i>, 135(13), e202217716.</li> <li>4. Nilsson, B. L., Soellner, M. B., &amp; Raines, R. T. (2005). Chemical synthesis of proteins. <i>Annu. Rev. Biophys. Biomol. Struct.</i>, 34(1), 91-118.</li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://doi.org/10.1007/s42398-018-0024-0">https://doi.org/10.1007/s42398-018-0024-0</a></li> <li>2. <a href="https://doi.org/10.1111/j.1574-6941.2001.tb00847.x">https://doi.org/10.1111/j.1574-6941.2001.tb00847.x</a></li> </ol>



<b>Title of the Course</b>	Microbial Biochemistry [P]	
<b>Course Code</b>	MIC-5001	
<b>Number of Credits</b>	01	
<b>Theory/Practical</b>	Practical	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	This course deals with the characteristics, properties and biological significance of the biomolecules of life. In depth knowledge of the energetics and regulation of different metabolic processes in microorganisms.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Estimation of various biomolecules.	PSO1, PSO4
	CO 2. Separate various biomolecules.	PSO1, PSO4, PSO5
	CO 3. Discriminate metabolic processes applicable to various biomolecules of the microbial origin.	PSO1, PSO4, PSO5
	CO 4. Explore microorganisms for their microbial products.	PSO1, PSO2, PSO4, PSO8

		No of hours	Mapped to CO	Cognitive Level
<b>Content:</b>	1. Standard curve for reducing sugar, total sugar and polysaccharide (starch).	02	CO1	K1
	2. Standard curve for protein (Folin Ciocalteau method).	02	CO1	K1
	3. Precipitation of protein from solution by salting out and dialysis.	06	CO2	K3
	4. Size exclusion (Gel filtration) chromatography.	06	CO2	K3
	5. Enzyme assay (Amylase), determination of Km and Vmax.	04	CO3, CO4	K4
	6. Specific activity, fold purification, percentage yield of enzyme.	02	CO3, CO4	K4
	7. Molecular weight determination by SDS-PAGE.	08	CO3, CO4	K4
<b>Pedagogy:</b>	Hands-on experiments in the laboratory, video, online data.			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Berg, J.M., Tymoczko, J.L., Gatto, G.J. and Stryer, L. (2023). Biochemistry, 10<sup>th</sup> Ed. W. H. Freeman &amp; Company, New York.</li> <li>2. Bull, A. T. and Meadow, P. (1978). Companion to Microbiology. Longman Group Limited, New York.</li> <li>3. Jayaraman, J. (2011). Laboratory Manual in Biochemistry, 2<sup>nd</sup> Ed. John Wiley &amp; Sons, Limited, Australia.</li> <li>4. Kennelly, P. J., Botham, K. M., McGuinness O.P., Rodwell, V. W., and Weil, P. A. (2022). Harper's Illustrated Biochemistry, 32<sup>nd</sup> ed. The McGraw-Hill Companies, Inc, New York.</li> <li>5. Lehninger, A., Cox, M. and Nelson, D. L. (2021). Principles of Biochemistry, 8<sup>th</sup> ed. W. H. Freeman &amp; Company, New York.</li> <li>6. Moat, A. G., Foster, J. W. and Spector, M. P. (2009). Microbial Physiology, 4<sup>th</sup> ed. A. John Wiley &amp; Sons Inc, USA.</li> <li>7. Plummer, D. T. (2017). An Introduction to Practical Biochemistry, 3<sup>rd</sup> ed. Tata McGraw Hill Publishing Company, New York.</li> <li>8. Sadasivam, S., Manickam, A. (2018). Biochemical Methods, 3<sup>rd</sup> ed. New Age International (P) Limited, New Delhi.</li> <li>9. Voet, D., Voet, J. G. and Pratt, C. W. (2018). Principles of Biochemistry, 5<sup>th</sup> ed. John Wiley and Sons Inc, USA.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Abo-Kamer, A.M., Abd-El-salam, I.S., Mostafa, F.A. et al. (2023). A promising microbial <math>\alpha</math>-amylase production, and purification from <i>Bacillus cereus</i> and its assessment as antibiofilm agent against <i>Pseudomonas aeruginosa</i> pathogen. Microb Cell Fact 22, 141.</li> </ol>			

	2. Raul D., Biswas T., Mukhopadhyay S., Kumar Das S., and Gupta S. (2014). Production and Partial Purification of Alpha Amylase from <i>Bacillus subtilis</i> (MTCC 121) Using Solid State Fermentation. <i>Biochem Res Int.</i> 568141. doi: 10.1155/2014/568141.
<b>Web Resources:</b>	1. <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC3066380/">https://pmc.ncbi.nlm.nih.gov/articles/PMC3066380/</a> 2. <a href="https://iopscience.iop.org/article/10.1088/1742-6596/1751/1/012096/pdf">https://iopscience.iop.org/article/10.1088/1742-6596/1751/1/012096/pdf</a>



<b>Title of the Course</b>	Microbial Genetics [T]
<b>Course Code</b>	MIC-5002
<b>Number of Credits</b>	3
<b>Theory/Practical</b>	Theory
<b>Level</b>	400
<b>Effective from AY</b>	2025-26
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

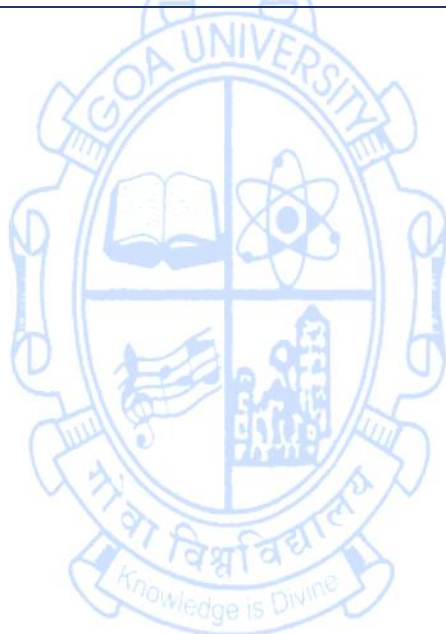
<b>Pre-requisites for the Course:</b>	It is assumed that students have basic knowledge of Mendelian genetics, structure of DNA and RNA, Prokaryotic and eukaryotic genome organisation, mutation concept, basic knowledge about replication, transcription.	
<b>Course Objectives:</b>	This course develops concept of Classical Mendelian genetics and deviation from Mendelian principles, Microbial genome organization (Prokaryotic and Eukaryotic), Viral Genetics, Mutagenesis and Bacterial plasmids. Understanding the concepts of replication, transcription and their regulation in prokaryotes and microbial eukaryotes.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1.Understanding the principles of classical Mendelian genetics and deviations from Mendelian inheritance in microbial systems.	PSO1
	CO 2.Describe the organization of microbial genomes, including prokaryotic, eukaryotic, and viral genetic elements.	PSO1, PSO2
	CO 3.Analyze the mechanisms of gene expression and regulation in prokaryotes and microbial eukaryotes.	PSO3, PSO4, PSO5

	CO 4. Illustrate the processes of DNA replication and transcription in microbial systems, and compare their regulatory mechanisms.		PSO3, PSO4	
	CO 5. Evaluate the role and impact of mutations and mutagenesis in microbial genetics and adaptation.		PSO4	
	CO 6. Interpret the genetic organization and functions of bacterial plasmids and their role in gene transfer.		PSO4, PSO5	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Microbial genome organization, gene regulation and genetic transfer.			
	1.1 Classical Mendelian genetics; deviation from Mendelian principles; Origin of mitochondria and plastids – Endosymbiotic theory, DNA in Mitochondria and plastids, Mitochondrial and plastid genes inherited by Non-Mendelian mechanism; Introduction to epigenetic inheritance.	<b>4</b>	CO1, CO2	K1, K2
	1.2 Prokaryotic & Eukaryotic genome size & structure, exceptions in prokaryotic genome (linear chromosome in <i>Borrelia burgdorferi</i> ); Introduction to synthetic genome ( <i>Mycoplasma genitalium</i> ), pseudogenes and their significance, C-value paradox, polyploidy in prokaryotes. Prokaryotic and Eukaryotic replication, transcription and regulation. Structure of Prokaryotic genes (lac and trp operon) and Eukaryotic Genes (interrupted Genes, intron splicing mechanisms). Microbial gene transfer (Conjugation, transformation, transduction).	<b>8</b>	CO2, CO3	K2, K3, K4
	1.3 Genomic organization, replication and regulation of Lytic and Lysogenic Phages - T4 and Lambda Phage.	<b>3</b>	CO2, CO3	K4, K5, K6
<b>Module 2:</b>	Genomic Rearrangements and Mutagenesis.			
	2.1. Mechanism of General and programmed DNA rearrangements, Antigenic and phase variation in bacteria. Transposons: IS elements – Composite transposons (Tn3, Tn10), Ty, Copia and P type, Mechanism of transposition. Role of transposons in DNA rearrangements, microbial genome evolution and drug	<b>6</b>	CO4, CO5	K3, K4, K5

	resistance. Deletion, duplication, inversion, translocation. Integrons and Genomic islands - pathogenicity islands.			
	<p>2.2. Mutagenesis, mutation and mutants: Somatic and germinal mutation, spontaneous and induced mutations, site directed mutagenesis using PCR and cassette mutagenesis, and random mutagenesis. Tautomeric shift, transition, transversion; Concept of clustered regularly interspaced short palindromic repeats (CRISPR) - Cas9.</p> <p><i>DNA Damage:</i> Thymine dimer, apyrimidinic site and apurinic site, cross linking, deamination of base, base mismatch. Types of mutations: silent mutation, missense mutation, nonsense mutation, Read through mutation, frameshift- insertion and deletion mutation, suppressor mutation, leaky mutation.</p> <p><i>Mutagenic chemicals and radiations and their mechanism of action:</i> Base analogues (5-Bromouracil and 2-amino purines), alkylating agents (EMS, NTG), Intercalating agents (acridines, Acriflavins), Hydroxylamine; mutagenic radiations- UV, X-rays and gamma rays. Ames test; Auxotrophy. Importance of mutations.</p>	9	CO4, CO5	K3, K4, K5 and K5
<b>Module 3:</b>	Fungal Genetics: Yeast - <i>Saccharomyces cerevisiae</i> / <i>Schizosaccharomyces pombe</i> and <i>Neurospora</i> genomes as model genetic systems; Chromosome replication, 2 $\mu$ plasmid, Yeast Artificial Chromosomes (YAC), tetrad analysis, genetic compatibility and non-compatibility genes, heterokaryosis, Parasexuality, Petite mutants of yeast, Killer yeast.	7	CO3, CO4, CO5	K1, K2, K3, K4 and K5
<b>Module 4:</b>	<p>Bacterial plasmids: Types of plasmids, F plasmids and their use in genetic analysis- F<sup>+</sup>/Hfr cells/ F' cells, Col plasmids, R plasmids- plasmids with genes encoding metal resistance and antibiotic resistance - efflux pump/MDR bacteria, degradative plasmids, Ti plasmid.</p> <p>Replication in plasmids. Concept of copy number (Col Plasmid) and compatibility.</p> <p>Bacterial plasmids as research tools.</p>	8	CO1, CO2	K1, K2, K3, K4, K5 and K6
<b>Pedagogy:</b>	<b>Lectures/tutorials/assignments/group discussion/seminar/ICT tools.</b>			
<b>Texts:</b>	1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). <i>Molecular biology of the cell</i> . (7 <sup>th</sup> Ed) Garland Science, New York.			

	<ol style="list-style-type: none"> <li>2. Dale, J. W., &amp; Park, S. F. (2010). <i>Molecular genetics of bacteria</i>. (5<sup>th</sup> Ed) John Wiley, New York.</li> <li>3. Freifelder, D. (1983). <i>Molecular biology: A comprehensive introduction to prokaryotes and eukaryotes</i>. (2<sup>nd</sup> Ed) Jane's Publishing Inc, New York.</li> <li>4. Gardner, E. J., Simmons, M. J., &amp; Snustad, D. P. (2006). <i>Principles of genetics</i>. (7<sup>th</sup> Ed) John Wiley &amp; Sons, New York.</li> <li>5. Green, M. R., &amp; Sambrook, J. (2014). <i>Molecular cloning: A laboratory manual</i>. (4<sup>th</sup> Ed) Cold Spring Harbor Laboratory Press, New York.</li> <li>6. Krebs, J. E., Lewin, B., Goldstein, E. S., &amp; Kilpatrick, S. T. (2014). <i>Lewin's genes XI</i>. Jones &amp; Bartlett Publishers, London.</li> <li>7. Maloy, S. R., Cronan, J. E., &amp; Freifelder, D. (1994). <i>Microbial genetics</i>. (2<sup>nd</sup> Ed) Jones &amp; Bartlett Publishers, London.</li> <li>8. Peter, J. R. (2016). <i>iGenetics: A molecular approach</i>. (3<sup>rd</sup> Ed) Pearson Education, New York.</li> <li>9. Sambrook, J., Fritsch, E. F., &amp; Maniatis, T. (1989). <i>Molecular cloning: A laboratory manual</i>. Cold Spring Harbor Laboratory Press, New York.</li> <li>10. Streips, U. N., &amp; Yasbin, R. E. (2004). <i>Modern microbial genetics</i>. John Wiley, New York.</li> <li>11. Snyder, L., Peters, J. E., Henkin, T. M., &amp; Champness, W. (2013). <i>Molecular genetics of bacteria</i>. ASM Press, USA.</li> <li>12. Trun, N., &amp; Trempy, J. (2003). <i>Fundamental bacterial genetics</i>. (2<sup>nd</sup> Ed) John Wiley &amp; Sons, New York.</li> <li>13. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., &amp; Losick, R. (2007). <i>Molecular biology of the gene</i>. (5<sup>th</sup> Ed) Pearson/Benjamin Cummings, New York.</li> </ol>
<p><b>References/ Readings:</b></p>	<ol style="list-style-type: none"> <li>1. Birnboim, H. C., &amp; Doly, J. (1979). A rapid alkaline extraction procedure for screening recombinant plasmid DNA. <i>Nucleic Acids Research</i>, 7(6), 1513–1523.</li> <li>2. Chiang, M., Brackley, C. A., Marenduzzo, D., &amp; Gilbert, N. (2022). Predicting genome organisation and function with mechanistic modelling. <i>Trends in Genetics</i>, 38(4), 364-378.</li> <li>3. Holmes, D. S., &amp; Quigley, M. (1981). A rapid boiling method for the preparation of bacterial plasmids. <i>Analytical Biochemistry</i>, 114(1), 193–197.</li> <li>4. Pretorius, I. S., &amp; Boeke, J. D. (2018). Yeast 2.0—connecting the dots in the construction of the world's first functional synthetic eukaryotic genome. <i>FEMS yeast research</i>, 18(4), 1-32.</li> </ol>

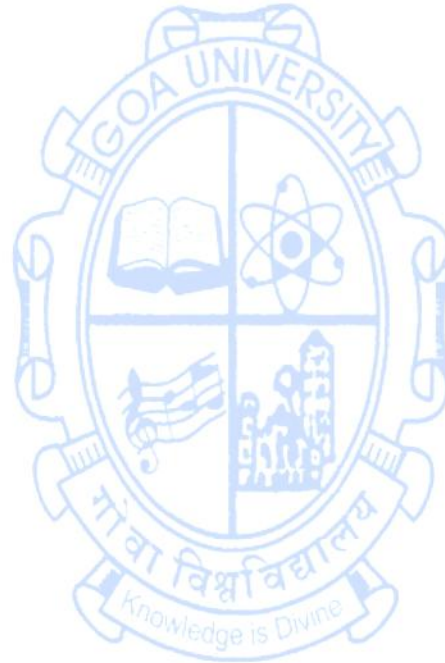
	<p>5. Bobay, L. M. (2020). The prokaryotic species concept and challenges. <i>The pangenome: Diversity, dynamics and evolution of genomes</i>, 21-49.</p> <p>6. Helinski, D. R. (2022). A brief history of plasmids. <i>EcoSal Plus</i>, 10(1), eESP-0028.</p>
<b>Web Resources:</b>	<p>1. <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC4379921/">https://pmc.ncbi.nlm.nih.gov/articles/PMC4379921/</a> (10.3389/fmicb.2015.00242)</p> <p>2. <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC8045676/">https://pmc.ncbi.nlm.nih.gov/articles/PMC8045676/</a> (10.1093/genetics/iyaa034)</p> <p>3. <a href="https://www.ncbi.nlm.nih.gov/books/NBK21114/">https://www.ncbi.nlm.nih.gov/books/NBK21114/</a></p> <p>4. <a href="https://www.ncbi.nlm.nih.gov/books/NBK21120/">https://www.ncbi.nlm.nih.gov/books/NBK21120/</a></p>



<b>Title of the Course</b>	Microbial Genetics [P]		
<b>Course Code</b>	MIC-5003		
<b>Number of Credits</b>	1		
<b>Theory/Practical</b>	Practical		
<b>Level</b>	400		
<b>Effective from AY</b>	2025-2026		
<b>New Course</b>	No		
<b>Bridge Course/ Value added Course</b>	No		
<b>Course for advanced learners</b>	No		
<b>Pre-requisites for the Course:</b>	Nil		
<b>Course Objectives:</b>	To learn the basic principles and techniques of microbial genetics.		
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>	
	CO 1. Identify and extract genomic and plasmid DNA	PSO1, PSO3, PSO4	
	CO 2. Estimate genomic and plasmid DNA	PSO3, PSO4	
	CO 3. Differentiate genomic and plasmid DNA	PSO3, PSO4	
	CO 4. Demonstrate mutagenesis for the development of strains	PSO5	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>
			<b>Cognitive Level</b>

1.	Isolation of genomic DNA from bacteria.	4	CO 1	K3, K4
2.	Isolation of plasmid DNA from bacterial cells by alkaline lysis method	6	CO1	K3, K4
3.	Spectrophotometric quantification and determination of purity of bacterial plasmid and genomic DNA	6	CO 2	K4, K5
4.	Agarose gel electrophoresis, visualization and documentation of plasmid and genomic DNA using Gel Doc system.	10	CO 3	K4, K5
5.	UV mutagenesis and screening of pigment deficient mutants of <i>Serratia marcescens</i> .	4	CO 4	K4,K5,K6
<b>Pedagogy:</b>	Hands-on experiments in the laboratory, video, online data			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Krebs J.E., Lewin B., Goldstein E.S. and Kilpatrick, S.T., (2014), LEWIS Genes,XI, Jones and Bartlett Publishers..</li> <li>2. Sambrook, J., Fritsch, E. F. and Maniatis, T., (1989), Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory, New York.</li> <li>3. Dale, J.W. and Park, S.F., (2010), Molecular Genetics of Bacteria, John Wiley.</li> <li>4. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K. and Walter, P., (2014), Molecular Biology of the Cell, Garland Science.</li> <li>5. Gardner, E.J., Simmons, M.J. and Snustad, D.P., (2006), Principles of Genetics, John Wiley &amp; Sons.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Birnboim, H.C. and Doly, J., (1979), A rapid alkaline extraction procedure for screening recombinant plasmid DNA. Nucleic Acid Research, 7: 1513-1523.</li> <li>2. Freifelder, D., (1983). Molecular biology, a comprehensive introduction to prokaryotes and eukaryotes. JANE'S PUBLISHING INC., BOSTON, MA(USA).</li> <li>3. Green, M. R. and Sambrook, J., (2014),Molecular Cloning: A laboratory manual, Cold Spring Harbour Laboratory Press, New York.</li> <li>4. Holmes, D.S. and Quigley, M., (2014),A rapid boiling method for the preparation of bacterial plasmids. Anal Biochem., 114(1): 193-197.</li> <li>5. Maloy, S. R., Cronan, J. E. and Freifelder, D., (1994),Microbial Genetics, Jones and Bartlett Publishers.</li> <li>6. Peter, J. R. (2016)., iGenetics: A Molecular Approach, Pearson Education.</li> </ol>			
<b>Web Resources:</b>	1. <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC7712542/">https://pmc.ncbi.nlm.nih.gov/articles/PMC7712542/</a>			

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|--|---|
|  | <ol style="list-style-type: none"><li>2. <a href="https://www.addgene.org/protocols/purify-plasmid-dna/">https://www.addgene.org/protocols/purify-plasmid-dna/</a></li><li>3. <a href="https://www.slideshare.net/slideshow/dna-quantification/238354753">https://www.slideshare.net/slideshow/dna-quantification/238354753</a></li></ol> |
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<b>Title of the Course</b>	Techniques and Instrumentation in Microbiology
<b>Course Code</b>	MIC-5004
<b>Number of Credits</b>	3
<b>Theory/Practical</b>	Theory
<b>Level</b>	400
<b>Effective from AY</b>	2025-2026
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	This course develops the concepts of methodology and instruments involved in studying the different components of microbial cells and their products.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Describe the various techniques and instruments used in study of microorganisms, metabolites, etc.	PSO1, PSO3
	CO 2. Interpret the observations collected using various techniques and instruments.	PSO2, PSO4
	CO 3. Outline the procedures and techniques used in investigation of microorganisms, metabolite, etc	PSO2, PSO3
	CO 4. Plan the strategies for analysis of microbial products.	PSO2, PSO4, PSO8

<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	1.1 Chromatographic techniques: Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), detectors, column/s matrix- Ion exchange, affinity and molecular exclusion. (using examples for separation of microbial lipids, fatty acids, pigments, nucleic acids and proteins/enzymes).	5	CO1, CO2, CO4	K1, K2
	1.2 Centrifugation: Principles, methodology, application, types: low speed, high speed and Ultracentrifugation (preparative and analytical) Density gradient centrifugation; Differential centrifugation	5		
	1.3 Spectroscopy: Atomic Absorption Spectrophotometry (AAS), UV-Visible, fluorimetry, Fourier transformation infra-red spectroscopy (FTIR), NMR, MS:MALDI-TOF.	5		
<b>Module 2:</b>	2.1 Microscopy: Phase Contrast, Epifluorescence filter technique (DEFT), SEM, TEM, Confocal and AFM. 2.2	5	CO1, CO2, CO3	K2, K3, K4
	2.2 Radio-isotope and tracer techniques: Isotope and types of isotopes, Radio-activity counters, Autoradiography, Radiorespirometry.	5		
	2.3 Cell and tissue culture techniques: Biohazards and Biosafety cabinet; Primary and secondary/established cell lines, Monolayer and suspension cultures, Fluorescence activated cell sorting (FACS).	5		
<b>Module 3:</b>	3.1 Electrophoretic technique: PAGE, IEF, Agarose gel electrophoresis, PFGE, DGGE, TGGE, Capillary electrophoresis, Single stranded conformation polymorphism (SSCP), Electroporator, Micro-array technique.	6	CO1, CO2, CO3, CO4	K3, K4
	3.2 Isolation of cell organelles: Different methods of cell lysis/ breakage and isolation and purification of various cell organelles - Cell surface structures, cell envelopes, plasma membranes, peptidoglycan, Outer membrane, ribosomes, protoplasts, vesicles, spheroplast, DNA, RNA. Separation of ribosomal subunits of bacteria	6		

	3.3 Other Bio-Instrumentation Techniques: X-ray diffraction, Oxygen analyser, Biosensors.	3		
<b>Pedagogy:</b>	<b>Lectures/tutorials/assignments/self-study</b>			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Arora M.P. (2020).Biophysics, Himalaya Publishing House, New Delhi</li> <li>2. Bajpai P.K. (2010) ,Biological Instrumentation &amp; methodology, 2nd revised edition, S.Chand and Co.</li> <li>3. Cooper, T. G. (2013), The Tools of Biochemistry, Wiley India Pvt. Ltd. Colowick, S. P. and Kaplan, N. O., Methods in Enzymology, Vol. VI, Academic Press, N.Y.</li> <li>4. Goswami, C., Paintal, A. and Narain, R. (2011), Handbook of Bioinstrumentation, Wisdom Press, New Delhi.</li> <li>5. Jayaraman, J. (2011), Laboratory Manual in Biochemistry, John Wiley &amp; Sons Limited, Australia.</li> <li>6. Mahesh S. (2018), Biotechnology-3. Including Molecular Biology and Biophysics, New Age International Pvt. Ltd Publishers, New Delhi.</li> <li>7. Norris, J. R. and Ribbons, D. W. (1971), Methods in Microbiology, Volume 5, Part B, Academic Press.</li> <li>8. Parakhia, M. V., Tomar, R. S., Patel, S. and Golakiya, B. A. (2010), Molecular Biology and Biotechnology: Microbial Methods, New India, Pitampura.</li> <li>9. Sambrook, J., Fritsch, E. F. and Maniatis, T. (2012), Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, USA.</li> <li>10. Wilson, K. and Walker, J. (2018), Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, N.Y., USA.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Partridge SR, Kwong SM, Firth N, and Jensen SO. (2018). Mobile Genetic Elements Associated with Antimicrobial Resistance. Clin Microbiol Rev 31:10.1128/cmr.00088-17.</li> <li>2. Mai HN, Cruz-Flores R, and Dhar AK. (2020). Development of an indirect Enzyme Linked Immunoassay (iELISA) using monoclonal antibodies against Photorhabdus insect related toxins, PirAVp and PirBVp released from <i>Vibrio</i> spp, Journal Microbiological Methods, 176:106002.</li> <li>3. Prior DJ, Lilly K, Seidemann M, Vaughan M, Becroft L, Easingwood R, et al. (2015). Making EBSD on water ice routine. J. Microsc., 259 (3) 237-256.</li> </ol>			
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://openstax.org/books/microbiology/pages/1-introduction">https://openstax.org/books/microbiology/pages/1-introduction</a></li> <li>2. <a href="https://pubmed.ncbi.nlm.nih.gov">https://pubmed.ncbi.nlm.nih.gov</a></li> <li>3. <a href="https://www.sciencedirect.com/journal/journal-of-microbiological-methods">https://www.sciencedirect.com/journal/journal-of-microbiological-methods</a></li> </ol>			

<b>Title of the Course</b>	Techniques and Instrumentation in Microbiology	
<b>Course Code</b>	MIC-5005	
<b>Number of Credits</b>	1	
<b>Theory/Practical</b>	Practical	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	This course develops the concepts of various techniques, methodology and instruments involved in studying the microbial cells and their products.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Analyse the microbial cell structures.	PSO 1, PSO 2, PSO 3, PSO 4
	CO 2. Examine the microbial metabolites and biomolecules.	PSO 1, PSO 2, PSO 3, PSO 4
	CO 3. Develop various methods for the processing of microbial cells and their products.	PSO 1, PSO 2, PSO 3, PSO 4, PSO 5, PSO 6
	CO 4. Interpret the activities of biomolecules.	PSO 1, PSO 2, PSO 3, PSO 4, PSO 5, PSO 6

<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>1.</b>	Analysis of the microbial cell structure using Phase contrast Microscopy.	<b>4</b>	CO1	K1, K4
<b>2.</b>	Counting of bacterial cells using epifluorescence microscopy.	<b>4</b>	CO2, CO4	K1, K5
<b>3.</b>	Cell disruption by sonicator and efficacy of sonication.	<b>4</b>	CO3	K1, K4
<b>4.</b>	Density gradient separation of microbial cells.	<b>4</b>	CO3, CO4	K1, K4
<b>5.</b>	Extraction of microbial pigments and profiling using UV-Vis spectroscopy.	<b>4</b>	CO3, CO4	K1, K2, K3
<b>6.</b>	Silica gel based adsorption chromatography for separation of pigments	<b>4</b>	CO4	K1, K3, K4
<b>7.</b>	Native Polyacrylamide gel electrophoresis (PAGE) for protein separation and Zymogram (Amylase or Protease).	<b>4</b>	CO4	K1, K3, K4
<b>8.</b>	Demonstration of HPLC, FT-IR, GC and spectral analysis.	<b>2</b>	CO4	K1, K2
<b>Pedagogy:</b>	Lectures/tutorials/assignments			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Edition to be specified or latest edition as applicable.</li> <li>2. Cooper, T.C., (1977) The Tools of Biochemistry. John Wiley &amp; Sons, New York.</li> <li>3. Colowick S. P., Kaplan N. O. (1967) Methods in Enzymology V Academic Press . New York</li> <li>4. Goswami, C., Paintal, A. and Narain, R., (2011) Handbook of Bioinstrumentation, Wisdom Press, New Delhi</li> <li>5. Jayaraman, J., (2011) Laboratory Manual in Biochemistry, John Wiley &amp; Sons Limited, Australia</li> <li>6. Mahesh S. (2018) Biotechnology-3. Including Molecular Biology and Biophysics, New Age International Pvt. Ltd Publishers, New Delhi</li> <li>7. Norris, J. R. and Ribbons, D. W., (1971) Methods in Microbiology, Volume 5, Part B, Academic Press. London</li> <li>8. Parakhia, M. V., Tomar, R. S., Patel, S. and Golakiya, B. A., (2010) Molecular Biology and Biotechnology: Microbial Methods, New India, Pitampura</li> <li>9. Sambrook, J., Fritsch, E. F. and Maniatis, T., (2012) Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, USA</li> <li>10. Wilson, K. and Walker, J., (2018) Principles and Techniques of Biochemistry and Molecular Biology, Cambridge</li> </ol>			

	University Press, N.Y., USA
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Nagayama, K., &amp; Danev, R. (2008). Phase contrast electron microscopy: development of thin-film phase plates and biological applications. <i>Philosophical Transactions of the Royal Society B: Biological Sciences</i>, 363(1500), 2153-2162.</li> <li>2. Lunau, M., Lemke, A., Walther, K., Martens-Habbena, W., &amp; Simon, M. (2005). An improved method for counting bacteria from sediments and turbid environments by epifluorescence microscopy. <i>Environmental Microbiology</i>, 7(7), 961-968.</li> <li>3. Gerde, J. A., Montalbo-Lomboy, M., Yao, L., Grewell, D., &amp; Wang, T. (2012). Evaluation of microalgae cell disruption by ultrasonic treatment. <i>Bioresour. Technol.</i>, 125, 175-181.</li> <li>4. Lin, L., Choudhary, A., Bavishi, A., Ogbonna, N., Maddux, S., &amp; Choudhary, M. (2012). Use of the sucrose gradient method for bacterial cell cycle synchronization. <i>Journal of microbiology &amp; biology education</i>, 13(1), 50-53.</li> <li>5. Mukherjee, G., &amp; Singh, S. K. (2011). Purification and characterization of a new red pigment from <i>Monascus purpureus</i> in submerged fermentation. <i>Process Biochemistry</i>, 46(1), 188-192.</li> <li>6. Strain, H. (1942). Chromatographic adsorption analysis. <i>Industrial &amp; Engineering Chemistry Analytical Edition</i>, 14(3), 245-249.</li> <li>7. Arndt, C., Koristka, S., Bartsch, H., &amp; Bachmann, M. (2012). Native polyacrylamide gels. <i>Protein electrophoresis: methods and protocols</i>, 49-53.</li> </ol>

<b>Title of the Course</b>	Biostatistics [T]	
<b>Course Code</b>	MIC-5006	
<b>Number of Credits</b>	3	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-26	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<p>The paper develops concepts about types of data observed in biological experiments, its handling and processing. It develops concepts of hypothesis and formulation of experiments.</p> <p>It gives understanding of various statistical operations needed to carry out and process the biological data.</p>	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Recognize and appreciate variation and diversity of biological data	PSO1, PSO4
	CO 2. Collect, generate and handle biological data	PSO1, PSO4
	CO 3. Processing of biological data independently	PSO1, PSO4
	CO 4. Analyze and classify biological data	PSO1, PSO4, PSO5

	CO 5. Choose appropriate method to process and analyze data		PSO4, PSO5, PSO6
	CO 6. Develop hypothesis and experimental plan		PSO4, PSO5, PSO6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	1.1 Characteristics of biological data: variables in biology (measurement, ranked, attributes), derived variables (ratio, index, rates), types of measurements of biological data and associated scales.	4	CO1, CO2 K1, K2
	1.2 Elementary theory of errors: exact and approximate numbers, source and classification of errors, decimal notation and rounding off numbers, absolute and relative errors, valid significant digits, relationship between number of valid digit and error, the error of sum, difference, product, quotient, power and root, rules of calculating digits, accuracy and precision, accuracy in observations.	6	CO1, CO2, CO3 K1, K2, K3, K4
	1.3 Measures of central tendency: characteristics of ideal measure, mean – simple, weighted, combined, and corrected mean, limitations of arithmetic mean; Median (for raw data, grouped data, continuous series), limitations of median; Mode (for individual series, grouped data - continuous frequency distribution) and limitations of modes; Relationship between mean, median and mode; mid-range, geometric mean, harmonic mean, partition value, quartiles, deciles, percentiles.	5	CO2, CO3, CO4 K2, K3, K4, K5
<b>Module 2:</b>	2.1 Measure of dispersion: variability, Range, mean deviation, coefficient of mean deviation, standard deviation (individual observations, grouped data, continuous series), variance, coefficient of variance, limitation. Skewness–definition, positive, negative, purpose, measure, relative measure, Karl Pearson’s Coefficient, Bowley’s Coefficient, Kelly’s Measure, Moments.	5	CO1, CO2, CO3, CO4 K2, K3, K4, K5
	2.2 Correlation analysis– Correlation, covariance, correlation coefficient for ungrouped data, Pearson’s Rank Correlation coefficient, scatter and dot diagram (graphical method). Regression analysis- Linear and exponential function- DNSA conversion by reducing sugar, survival/growth of bacteria, regression coefficients, properties, standard error of estimates, prediction, regression	5	CO1, CO2, CO3, CO4, CO5 K2, K3, K4, K5, K6

	analysis for linear equation.			
	2.3 Probability: Probability, Combinatorial Techniques, Elementary Genetics, Conditional Probability, Bayes' Rule, Statistical Independence, Binomial, Poisson, Normal Distributions.	5	CO1, CO2, CO3, CO4, CO5	K2, K3, K4, K5
<b>Module 3:</b>	3.1 Hypothesis Testing– comparison between parameter and statistics, sampling theory, sampling and non-sampling error, estimation theory, confidence interval, limits and relation with hypothesis, test of significance; Normality test, Z-test, application of Z-test, Students' t-test, t-distribution, computation, paired t-test.	8	CO1, CO2, CO3, CO4, CO5, CO6	K2, K3, K4, K5, K6
	3.2 Chi-square test for independence and test for significance, applications and limitations	3	CO1, CO2, CO3, CO4, CO5, CO6	K2, K3, K4, K5, K6
	3.3 F-test, One way ANOVA, applications and limitations	4	CO1, CO2, CO3, CO4, CO5, CO6	K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments/MOODLE/Videos/ICT tools/Software			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Arora, P. N. and Malhan, P. K., (2020), Biostatistics, Himalaya Publishing House, India.</li> <li>2. Cochran, WG and Snedecor, GW Statistical Methods. (1989) Iowa State University Press, Ames.</li> <li>3. Danilina, N.I., Dubrovskaya, N.S. Kvasha, O.P. and Smirnov, G.L., (1988) Computational Mathematics, Mir Publishers, Moscow</li> <li>4. Kothari, C. R., (2013) Quantitative Techniques, Vikas Publishing House, New Delhi.</li> <li>5. Le, C.T. (2003), Introductory Biostatistics, John Wiley &amp; Sons, Inc, New Jersey</li> <li>6. Rosner, B. (2010), Fundamentals of Biostatistics, 7<sup>th</sup> Edition, Brooks/Cole, Cengage Learning Inc, USA.</li> <li>7. Surya, R. K., (2018) Biostatistics, Himalaya Publishing House, India</li> </ol>			
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. Experimental Methods in Agriculture - <a href="https://www.statforbiology.com/statbookeng/index.html">https://www.statforbiology.com/statbookeng/index.html</a></li> <li>2. Jamovi (R based statistical tool) - <a href="https://youtu.be/mZomeS0tLxY?list=PLkf8Hk_ojuOKJwvgrnldauAbf18CFd68I">https://youtu.be/mZomeS0tLxY?list=PLkf8Hk_ojuOKJwvgrnldauAbf18CFd68I</a></li> </ol>			

<b>Title of the Course</b>	Biostatistics [P]	
<b>Course Code</b>	MIC-5007	
<b>Number of Credits</b>	1	
<b>Theory/Practical</b>	Practical	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<ol style="list-style-type: none"> <li>1. The paper develops concepts about types of data observed in biological experiments, its handling and processing.</li> <li>2. It develops concepts of hypothesis and formulation of experiments.</li> <li>3. It gives understanding of various statistical operations needed to process the biological data.</li> </ol>	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Collect and process the biological data.	PSO1, PSO2, PSO4
	CO 2. Classify and analyse the biological data.	PSO3, PSO4
	CO 3. Evaluating the statistical tool for biological experiments.	PSO3, PSO4
	CO 4. Develop the hypothesis and experimental plan.	PSO3, PSO5

	CO 5. Software based learning statistical analysis		PSO3, PSO5
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Spreadsheet - data handling, processing, analysis and graph preparation.	2	CO1, CO2 K2, K4
<b>Module 2:</b>	Linear equation analysis (regression analysis).	8	CO1, CO2 K2, K4
<b>Module 3:</b>	Normal distribution.	8	CO3, CO4 K3
<b>Module 4:</b>	Hypothesis testing (T Test, Z test, F test).	10	CO3, CO4 K5
<b>Module 5:</b>	Application of statistical software for analysis.	2	CO5 K4
<b>Pedagogy:</b>	Data collection and analysis, ICT tools		
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Arora, P. N. and Malhan, P. K., (2020) Biostatistics, (1st Edition) Himalaya Publishing House. Nagpur</li> <li>2. Kothari, C. R., (2013) Quantitative Techniques, (3rd Edition) Vikas Publishing House. New Delhi</li> <li>3. Rastogi V. B. (2009) Fundamentals of Biostatistics. (2nd Edition) Ane Books Pvt. Ltd. New Delhi</li> <li>4. Snedecor, G.W. and Cochran, W.G. (1989) Statistical Methods. (8th Edition), Iowa State University Press, Ames.</li> <li>5. Surya, R. K., (2018) Biostatistics, (1st Edition) Himalaya Publishing House. Nagpur</li> </ol>		
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Agresti, A. (1996). An Introduction to Categorical Data Analysis. (2nd Ed) John Wiley; Sons, New York.</li> <li>2. Andersen, K., Ornulf B, Gill R., and Keiding N. (1996). Statistical Models Based on Counting Processes. (1st Ed) Springer Series in Statistics, Berlin.</li> <li>3. Chance, Beth, and Allan Rossman. (2018). Investigating Statistics, Concepts, Applications, and Methods. (3rd ed). Duxbury Press, London.</li> <li>4. Hastie, T., R. Tibshirani, and J. Friedman. (2001). The Elements of Statistical Learning. Springer. Berlin</li> </ol>		
<b>Web Resources:</b>	<a href="https://doi.org/10.4103/0253-7613.99297">https://doi.org/10.4103/0253-7613.99297</a> <a href="https://www.mjrheum.org/assets/files/792/file195_1052.pdf">https://www.mjrheum.org/assets/files/792/file195_1052.pdf</a>		

### Discipline Specific Elective Courses

<b>Title of the Course</b>	Environmental Microbiology and Bioremediation [T]	
<b>Course Code</b>	MIC-5201	
<b>Number of Credits</b>	3	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	NIL	
<b>Course Objectives:</b>	To introduce the concepts of microbial diversity, community structure, role of microorganisms in biogeochemical cycles and sustainable development. Application of microorganisms for biomonitoring and microbial bioremediation of pollutants. Designing of waste treatment plants and Valorization of agro waste.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Demonstrate the role of microorganisms in biogeochemical cycling of nutrients and analyse impact of pollution on ecosystems.	PSO3, PSO4, PSO7
	CO 2. Apply the principles of bioremediation for sustainable development.	PSO2, PSO5, PSO6, PSO7, PSO8
	CO 3. Analyse culture independent and culture dependent methods to understand and correlate	PSO1, PSO4, PSO5

	the microbial diversity with community structure.			
	CO 4. Compare different econiches and their microbial diversity.		PSO1, PSO2	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	<b>Microbial Ecology.</b>			
	<b>Ecosystems:</b> Concept of ecosystem, habitat, econiche. Components and functioning of ecosystem, Microbial interactions with biotic environment. Ecological pyramids, energy flow, food chain and food web. Concepts of microbial guild, <i>r</i> and <i>k</i> selection concept, role of microbes in ecological succession.	<b>4</b>	CO3, CO4	K1, K2
	<b>Microbial diversity in ecosystem and Community structure:</b> The expanse and estimates/measurement of microbial diversity- Rankabundance curve (species richness and evenness), indices of diversity (Shannon index, simpson index, Gini-simpson index), Culture based microbial diversity, Newer high throughput approaches (extinction culture, diffusion chamber/ichip, gel micro droplet method, co-culture method, flow cytometry) for exploring microbial diversity from environmental samples. Culture independent molecular methods (DGGE, FISH, phylochips, metagenomic library) for understanding microbial community structure. Metabolic diversity of microbial communities in diverse environments (aquatic and terrestrial).	<b>8</b>	CO3, CO4	K2, K3, K4, K5
	<b>Microbial biofilms in environment:</b> Quorum sensing in bacteria; Nature and significance, Microbial mat.	<b>3</b>	CO2,CO4	K3, K4, K5
<b>Module 2:</b>	<b>Biogeochemical processes, Pollution and sustainable development.</b>			
	<b>Biogeochemical cycles:</b> Physiological, biochemical, microbiological aspects of carbon, nitrogen, phosphorous, sulphur, Fe and Mn cycles.	<b>7</b>	CO1, CO2, CO4	K4, K5

	<b>Impacts of pollution on ecosystem and Concepts of sustainable development:</b> Effect of marine pollutants on productivity and sustainability of aquatic and terrestrial econiche. Eutrophication, HABs, biomagnification. Ballast water and significance of invasive microorganisms. Climate change and occurrence of microbial diseases. Environment impact assessment (EIA) studies. Concept of sustainable development and application of microorganisms towards sustainable development; Microorganisms for clean energy.	8	CO1, CO2	K3, K4
<b>Module 3:</b>	<b>Biomonitoring and microbial bioremediation of pollutants.</b>			
	Application of microorganisms for pollution Biomonitoring-biotracers and biosensors, microbes as Bioindicators.	2	CO1,CO2	K3, K5, K6
	<b>Bioremediation technologies:</b> Microorganisms for bioremediation of oil spills (biodegradation, bioaugmentation, biostimulation, biosurfactants) heavy metals, xenobiotics (biotransformation, cometabolism) and recalcitrant pesticides.	5	CO2	K3, K5, K6
	<b>Waste water treatment plants:</b> Primary, secondary and tertiary treatment of waste water. Concept of microbial consortia and microbial biofilms in waste management and pollution abatement.	4	CO2	K3, K4, K5, K6
	<b>Valorization of agro waste:</b> Containing lignin, cellulose and pectin. Intimate coupling of photocatalysis and microbial biodegradation (ICPB) for advanced treatment of organic pollutants.	4	CO2, CO3	K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments/presentations			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Gasol, J.M. and Kirchman, D. L. (2018) Microbial Ecology of the Oceans (3<sup>rd</sup> Edition). Wiley Publishers (USA).</li> <li>2. Liu, W-T. and Jansson, J. K. (2010) Environmental Molecular Microbiology. Caister Academic Press (N.Y. USA).</li> <li>3. Medigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., &amp; Stahl, D. A. (2018) Brock Biology of Microorganisms (15<sup>th</sup> Edition). Pearson. (UK)</li> <li>4. Meena, S., Naik M.M. (2019) Advances in biological science research: A practical approach. Academic press (New York USA).</li> <li>5. Molina, G., Usmani, Z., Sharma, M. et al. (2023) Microbial bioprocessing of Agri-Food waste (1<sup>st</sup> Edition). CRC Press (Florida USA).</li> </ol>			

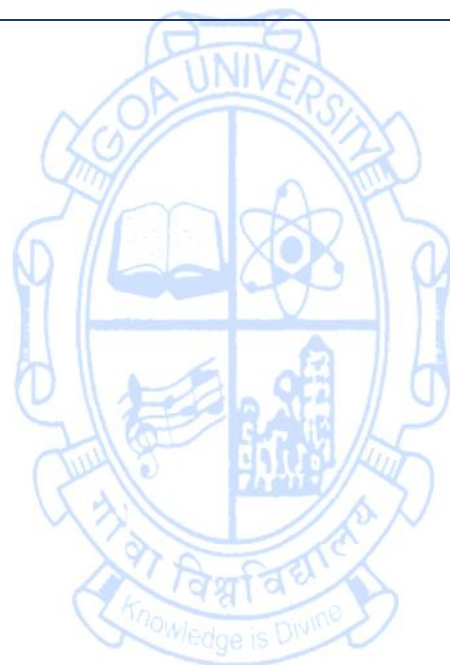
	<ol style="list-style-type: none"> <li>6. Morajkar, P.P., Naik, M.M. (2023) Advances in nano and biochemistry. Environmental and Biomedical applications. Academic press (New York USA).</li> <li>7. Munn, C. (2020) Marine Microbiology: Ecology and Applications (3<sup>rd</sup> Edition). Garland Science, Taylor and Francis Group, (Florida, USA).</li> <li>8. Murugesan, A. G and Rajakumari, C. (2019) Environmental Science and Biotechnology: Theory and Techniques. MJP Publishers (Tamil Nadu, India).</li> <li>9. Naik, M. and Dubey, S. K. (2017) Marine Pollution and Microbial Remediation. Springer Nature (Singapore).</li> <li>10. Norris, J. R. and Ribbons, D.W. (2012). Methods in Microbiology. (Editions 18 &amp; 19). Academic Press (N.Y. USA).</li> <li>11. Osborn, M and Smith, C. (2005) Molecular Microbial Ecology (1<sup>st</sup> Edition). Taylor and Francis (London, UK).</li> <li>12. Satyanarayana, T., Johri, B. and Anil, T. (2012) Microorganisms in Environmental Management: Microbes and Environment. Springer (Singapore).</li> <li>13. Scragg, A. H. (2005) Environmental Biotechnology (2<sup>nd</sup> Edition). Oxford University Press. (England, UK).</li> <li>14. Willey, J. M., Sandman, K. M. and Wood, D. H. (2020) Prescott's Microbiology (11<sup>th</sup> Edition). McGraw-hill Education.</li> </ol>
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Cavicchioli, R., Ripple, W. J., Timmis, K. N., Azam, F et al. (2019) Scientists' warning to humanity: microorganisms and climate change. Nature reviews microbiology, 17, 569- 586.</li> <li>2. Kennish, M. J. (2017) Practical Handbook of Estuarine and Marine Pollution. CRC Press, Francis and Taylor (Florida, USA).</li> <li>3. King, R. B., Sheldon, J. K. and Long, G. M. (1997) Practical Environmental Bioremediation: The Field Guide (Second edition). CRC Press (Florida, USA)..</li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://www.epa.gov/nutrientpollution/effects-dead-zones-and-harmful-algal-blooms">USEPA: https://www.epa.gov/nutrientpollution/effects-dead-zones-and-harmful-algal-blooms</a></li> <li>2. <a href="https://www.epa.gov/marine-protection-permitting/protecting-our-oceans-pollution">USEPA: https://www.epa.gov/marine-protection-permitting/protecting-our-oceans-pollution</a></li> <li>3. <a href="https://cpcb.nic.in/env-protection-act/">https://cpcb.nic.in/env-protection-act/</a></li> <li>4. <a href="https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2022.971228/full">https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2022.971228/full</a></li> <li>5. <a href="https://hal.science/hal-04152835/file/Meyer%20et%20al%202023.pdf">https://hal.science/hal-04152835/file/Meyer et al 2023.pdf</a></li> </ol>

<b>Title of the Course</b>	Environmental Microbiology and Bioremediation [P]	
<b>Course Code</b>	MIC-5202	
<b>Number of Credits</b>	1	
<b>Theory/Practical</b>	Practical	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	To familiarize with the techniques of waste water analysis, biodegradation of aromatic pollutants and bioremediation of metal/metalloid pollutants.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Evaluate quality of water for pollution.	PSO 1, PSO 2, PSO 3, PSO 4
	CO 2. Isolate microorganisms with specialized bioremedial potential.	PSO 1, PSO 2, PSO 3, PSO 4, PSO 5
	CO 3. Establish the microbial physiology for bioremedial applications.	PSO 1, PSO 2, PSO 3, PSO 4, PSO 5
	CO 4. Demonstrate the role of microorganisms in pollution abatement.	PSO 1, PSO 2, PSO 3

<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1</b>	1. Analysis of water samples for COD, BOD and microbial load.	6	CO1	K2, K4
	2. Isolation of hydrocarbon degrading microorganism (degradation of sodium benzoate/Naphthalene).	6	CO2, CO4	K2, K3
	3. Isolation of biosurfactant producing microorganisms.	6	CO2, CO4	K2, K3
	4. BATH assay for microbial adherence.	6	CO3, CO4	K2, K3, K4, K5, K6
	5. Isolation of selenite/tellurite resistant microorganisms for application in bioremediation.	6	CO2, CO4	K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Hands-on experiments in the laboratory, video, online data			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Liu, W-T. and Jansson, J. K. (2010) Environmental Molecular Microbiology. (1<sup>st</sup> Edition). Caister Academic Press. United Kingdom.</li> <li>Medigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., &amp; Stahl, D. A. (2017) Brock Biology of Microorganisms. (15<sup>th</sup> Edition). Pearson.</li> <li>Goasol, R. and Kirchman, D. L. (2018) Microbial Ecology of the Oceans. (3<sup>rd</sup> Edition). Wiley Publishers. USA.</li> <li>Munn, C. (2019). Marine Microbiology: Ecology &amp; Applications (3<sup>rd</sup> Edition). CRC Press. Boca Raton.</li> <li>Murugesan, A. G. and Rajakumari, C. (2019) Environmental Science and Biotechnology: Theory and Techniques. (1<sup>st</sup> Edition). MJP Publishers. Chennai, India.</li> <li>Naik, M. and Dubey, S. K. (2017) Marine Pollution and Microbial Remediation. (1<sup>st</sup> Edition). Springer Publications.</li> <li>Norris, J. R. and Ribbons, D.W. (2012) Methods in Microbiology. (1<sup>st</sup> Edition). Vol. 18 &amp; 19, Academic Press. New York</li> <li>Osborn, A. M. and Smith, C. J. (2005) Molecular Microbial Ecology. (1<sup>st</sup> Edition). Taylor and Francis. London.</li> <li>Satyanarayana, T., Johri, B. and Anil, T. (2012) Microorganisms in Environmental Management. (1<sup>st</sup> Edition). Springer Dordrecht</li> <li>Willey, J. M., Sherwood, L. M., &amp; Woolverton, C.J. (2016) Prescott's Microbiology. (11<sup>th</sup> Edition). McGraw-hill Education. New York.</li> </ol>			

**References/  
Readings:**

1. Cavicchioli, R., Ripple, W. J., Timmis, K. N., Azam, F et al. (2019). Scientists' warning to humanity: microorganisms and climate change. Nature reviews microbiology, 17, 569- 586. <https://doi.org/10.1038/s41579-019-0222-5>
2. Kennish, M. J. (2017) Practical Handbook of Estuarine and Marine Pollution. CRC Press, Francis and Taylor. <https://doi.org/10.1201/9780203742488>
3. King, R. B., Sheldon, J. K., & Long, G. M. (1997) Practical Environmental Bioremediation: The Field Guide. (2<sup>nd</sup> Edition). CRC Press.

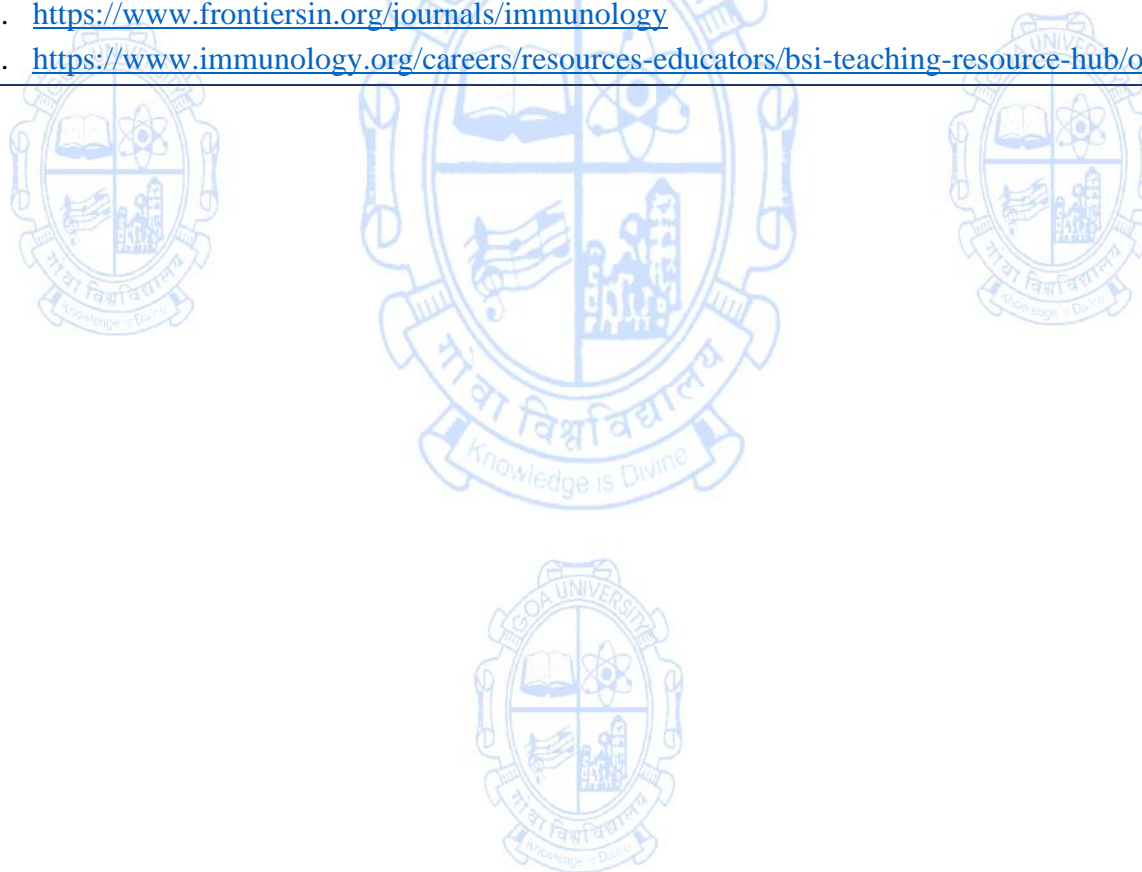


<b>Title of the Course</b>	Immunology [T]	
<b>Course Code</b>	MIC-5203	
<b>Number of Credits</b>	3	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-26	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<ol style="list-style-type: none"> <li>To understand the concepts and mechanisms in the functioning of immunological cells and their interactions.</li> <li>To get acquainted with the regulations of molecule synthesis, signalling, immune responses and allied activities of immune system at the molecular level.</li> </ol>	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1.Explain the mechanisms of immunological responses.	PSO 1, PSO 2, PSO4
	CO 2.Demonstrate the role of cellular ontogeny and the gene rearrangement in complex immune system.	PSO 1, PSO 4, PSO 5
	CO 3.Apply the principles of immunology for immunodiagnostics.	PSO 2, PSO 4, PSO 5, PSO 8
	CO 4.Correlate the clinical symptoms with imunological diseases.	PSO 1, PSO 2, PSO 4, PSO 8

	CO 5. Provide overview of immune system and interactions.		PSO 1, PSO 2, PSO 4, PSO 7, PSO 8
Content:		No of hours	Mapped to CO Cognitive Level
<b>Module 1: 1.1</b>	Phagocytosis – Cell surface receptors/markers and their role, killing mechanisms; NK cells – Cell to cell recognition for normal and modified cells, receptors, initiation of apoptosis and killing of target cells, malfunctioning of NK cells; role of mast cells in immunity.	5	CO2, CO5 K2, K3, K4
<b>Module 1: 1.2</b>	Classification and concepts of immunoglobulin domain, distribution of immunoglobulin domain, superfamily member, structure and function of TCR and BCR, diversity of antigen binding domain, concept of segmented gene, gene organization of Ig and TCR, rearrangement and generation of gene during differentiation and development of B and T Cells, expression of Ig and TCR Cistrons, class switch and regulation of expression, B and T Cell ontogeny.	5	CO2, CO5 K2, K3, K4, K5
<b>Module 1: 1.3</b>	Major Histocompatibility Cluster – Introduction to MHC I, II and III, structure and function of MHC I and II, distribution and recognition of MHC I and II, gene organisation and concept of polymorphism, expression and its regulation, processing of extracellular antigen by APC, presentation of intracellular antigen by nucleated cells, recognition of MHC I and II by TCR/CD3 complex; Members of MHC III and their roles (in brief).	5	CO1, CO5 K2, K3, K4, K5
<b>Module 2: 2.1</b>	Immunocompetent T and B cells, recognition, signaling and activation of T cells by APC, control and regulation of activated T Cells, B-cell activation – Type 1 thymus-independent antigen, Type 2 thymus-independent antigen, thymus dependent antigen, co operation with T-cells and activation of resting B-cells, antigen processing by B-cells, stimulation by cross-linking surface Ig.	5	CO1, CO5 K2, K3, K4
<b>Module 2: 2.2</b>	Cytokine as messengers, receptor for cytokine – gp130 subfamily, 5 beta-c and gamma-c receptor subfamily, signal transduction and effects, network	5	CO1, CO5 K2, K3, K4, K5

	interactions; TH1 and TH2 responses; Cytokine mediated chronic inflammatory response; Killer T Cell and its regulation; effect of antigen dose and maturation of affinity of antibodies; role of memory cells.			
<b>Module 2: 2.3</b>	Antigen as major factor in control, feedback control of antibody production, T cell regulation – T-helper cells, T-cell suppression; Idiotypic networks, influence of genetic factors, immune regulation through hormone; T-cell tolerance.	5	CO3	K2, K4, K5
<b>Module 3: 3.1</b>	Concept of inflammation, complement fixation, defense against intracellular bacterial pathogen, immunity to viral infection, immunity to fungi, immunity to parasitic infections; Passively acquired immunity, vaccination – herd immunity, strategies, killed organisms as vaccines, live attenuated vaccines, subunit vaccine, epitope vaccines, vaccines in use and experimental vaccines, Adjuvant and new approaches in vaccine development.	5	CO5	K1, K2, K3, K6
<b>Module 3: 3.2</b>	Immuno-techniques: Antigen antibody interactions in solution, identification and measurement of antigen, epitope mapping, hybridoma technology and monoclonal antibody revolution, catalytic antibodies, engineering antibodies, antigen-antibody based affinity chromatography, isolation of leukocyte and subpopulations, localization of antigen in cyto and in tissue, assessment of functional activity, genetic engineering of experimental animal for immune response investigation. Immuno-assays and their application: ELISA, SRID RIA, Immuno fluorescence, Western Blotting.	5	CO3	K2, K3, K4, K5, K6
<b>Module 3: 3.3</b>	Clinical immunology (Immunodeficiency): phagocytic cell defects, complement system deficiency, primary B-cell deficiency, primary T-cell deficiency, combined immunodeficiency, secondary immunodeficiency, comparison between SCID and AIDS, recognition of immunodeficiency.	5	CO4	K1, K2, K4, K5
<b>Pedagogy:</b>	Lectures/tutorials/assignments/Moodle/videos			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Abbas, A. K., Lichtman, A. H., &amp; Pillai, S. Cellular and molecular immunology. Elsevier Health Sciences. (2021).</li> <li>2. Chakraborty, P. and Pal, N. K., Manual of Practical Microbiology and Parasitology, New Central Book Agency (P) Ltd, Delhi, India. (2004).</li> </ol>			

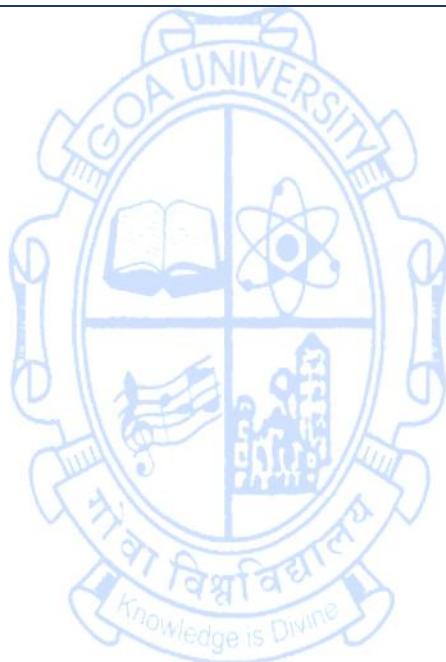
	<ol style="list-style-type: none"> <li>3. Bona, C. A. and Bonilla, F. A., Textbook of Immunology, Fine Arts Press. (1996).</li> <li>4. Delves, P., Martin, S., Burton, D. and Roitt, I., Roitt's Essential Immunology. Wiley-Blackwell. (2017).</li> <li>5. Goldsby, R. A., Kindt, T.J. and Osborne, B.A., Kuby Immunology. W.H. Freeman. (2007).</li> <li>6. Murphy, K., Janeway's Immunobiology, Garland Science. (2007).</li> </ol>
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Marshall, J. S., Warrington, R., Watson, W., &amp; Kim, H. L. (2018). An introduction to immunology and immunopathology. <i>Allergy, asthma, and clinical immunology: official journal of the Canadian Society of Allergy and Clinical Immunology</i>, 14(Suppl 2), 49.</li> <li>2. Chi, Hongbo et al. (2024). Principles and therapeutic applications of adaptive immunity. <i>Cell</i>, 187(9): 2052 – 2078.</li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://www.nature.com/ni/">https://www.nature.com/ni/</a></li> <li>2. <a href="https://www.frontiersin.org/journals/immunology">https://www.frontiersin.org/journals/immunology</a></li> <li>3. <a href="https://www.immunology.org/careers/resources-educators/bsi-teaching-resource-hub/online-teaching-resources">https://www.immunology.org/careers/resources-educators/bsi-teaching-resource-hub/online-teaching-resources</a></li> </ol>



<b>Title of the Course</b>	Immunology [P]		
<b>Course Code</b>	MIC-5204		
<b>Number of Credits</b>	01		
<b>Theory/Practical</b>	Practical		
<b>Level</b>	400		
<b>Effective from AY</b>	2025-26		
<b>New Course</b>	No		
<b>Bridge Course/ Value added Course</b>	No		
<b>Course for advanced learners</b>	No		
<b>Pre-requisites for the Course:</b>	Nil		
<b>Course Objectives:</b>	Hands-on practice for various techniques used in immunology.		
<b>Course Outcomes:</b>			<b>Mapped to PSO</b>
	CO 1. Explain the principle of various immunodiagnostics.		PSO3
	CO 2. Demonstrate the techniques used in immuno-diagnosis.		PSO3
	CO 3. Perform the various immunological techniques for diagnosis of various diseases.		PSO4
	CO 4. Develop novel and rapid immunodiagnostics.		PSO6
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>

1.	Haemagglutination: Blood grouping - ABO and Rh systems	2	CO1, CO3	K2,K3,K4
2.	Immunodiffusion slide technique	4	CO1, CO3	K2,K3,K4
3.	Agglutination tests for <i>Salmonella</i> -antigens	4	CO1, CO3	K2,K3,K4
4.	Complement fixation test	4	CO1, CO2	K2,K3,K4
5.	C-reactive protein determination	4	CO1, CO2	K2,K3,K4
6.	ELISA	4	CO1, CO2	K5,K6
7.	Rapid tests – Malaria antigens Pv/Pf, IgM/IgG antibodies for Dengue, Hepatitis HBsAg	4	CO3, CO4	K4,K5
8.	Rheumatoid Arthritis Factor determination	4	CO1, CO2	K2,K3,K4
<b>Pedagogy:</b>	Hands-on experiments in the laboratory, video, online data			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Abbas, A. K., Lichtman, A. H. and Pillai, S. (2021). Cellular and Molecular Immunology, Elsevier Health Sciences, Philadelphia, PA.</li> <li>2. Chakraborty, P. and Pal, N. K. (2004). Manual of Practical Microbiology and Parasitology, New Central Book Agency (P) Ltd., Delhi, India.</li> <li>3. Delves, P., Martin, S., Burton, D. and Roitt, I. (2017). Roitt's Essential Immunology, Wiley-Blackwell, Hoboken, NJ.</li> <li>4. Hay, F. C. and Westwood, O. M. R. (2002). Practical Immunology, Blackwell Science, Oxford.</li> <li>5. Miller, L. E. (2021). Clinical Immunology and Serology: A Laboratory Perspective (5th ed.), F. A. Davis Company, Philadelphia, PA.</li> <li>6. Murphy, K. (2007). Janeway's Immunobiology, Garland Science, New York, NY.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Hayrapetyan, H., Tran, T., Tellez-Corrales, E., &amp; Madiraju, C. (2023). Enzyme-linked immunosorbent assay: Types and applications. In R. S. Matson (Ed.), <i>ELISA. Methods in Molecular Biology</i> (Vol. 2612, pp. 1–15). Humana, New York, NY. <a href="https://doi.org/10.1007/978-1-0716-2903-1_1">https://doi.org/10.1007/978-1-0716-2903-1_1</a></li> <li>2. Mata, V. E., Andrade, C. A. F., Passos, S. R. L., Hökerberg, Y. H. M., Fukuoka, L. V. B., &amp; Silva, S. A. D. (2020). Rapid immunochromatographic tests for the diagnosis of dengue: A systematic review and meta-analysis. <i>Cadernos de Saúde Pública</i>, 36(6), e00225618. <a href="https://doi.org/10.1590/0102-311X00225618">https://doi.org/10.1590/0102-311X00225618</a></li> </ol>			

	<p>3. Pathak, A., &amp; Agrawal, A. (2019). Evolution of C-reactive protein. <i>Frontiers in Immunology</i>, 10, 943. <a href="https://doi.org/10.3389/fimmu.2019.00943">https://doi.org/10.3389/fimmu.2019.00943</a></p> <p>4. Xiao, Y., Thompson, A. J., &amp; Howell, J. (2020). Point-of-care tests for hepatitis B: An overview. <i>Cells</i>, 9(10), 2233. <a href="https://doi.org/10.3390/cells9102233">https://doi.org/10.3390/cells9102233</a></p>
<b>Web Resources:</b>	<p>1. <a href="https://www.biointeractive.org/classroom-resources/immunology-virtual-lab">https://www.biointeractive.org/classroom-resources/immunology-virtual-lab</a></p> <p>2. <a href="https://biologynotesonline.com/category/practical/immunology-practical/">https://biologynotesonline.com/category/practical/immunology-practical/</a></p>



## SEMESTER II

### Discipline Specific Core Courses

<b>Title of the Course</b>	Microbial Taxonomy and Systematics	
<b>Course Code</b>	MIC-5008	
<b>Number of Credits</b>	3	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	500	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	1. To introduce the concepts, tools and techniques of taxonomy and systematics of the microbial world. 2. To introduce the salient features of various microbial groups and their underlying diversity.	
<b>Course Outcomes:</b>	CO 1. Associate the standard rules of classification systems to categorize microorganisms	<b>Mapped to PSO</b> PSO 1, PSO 2, PSO 3
	CO 2. Discuss the dynamic and developing nature of the field of microbial taxonomy and systematics.	PSO 1, PSO 2, PSO 3, PSO 4

	CO 3. Classify the microorganisms on the basis of their characters.		PSO 1, PSO 2, PSO 3, PSO 4, PSO 5	
	CO 4. Appraise the applications of taxonomic tools.		PSO 1, PSO 2, PSO 3, PSO 4, PSO 5, PSO 6	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	<b>Microbial taxonomy and systematics:</b> Concepts of taxonomy (characterization, classification and nomenclature) and systematics; binomial classification and taxonomic hierarchy of microorganisms, three domain, six-kingdom, 8-kingdom systems, Endosymbiotic theory.	7	CO2, CO3, CO4	K1, K2
	<b>Phenotypic characters:</b> Morphology, Biochemical tests (e.g. API, BIOLOG), Bacteriophage typing, Serotyping.	5	CO2, CO3, CO4	K2, K3, K4
	<b>Concepts of species, numerical taxonomy and polyphasic taxonomy.</b>	3	CO1	K1, K2, K3, K4
<b>Module 2:</b>	<b>Chemotaxonomic markers:</b> Cell wall components, lipid composition, cellular fatty acid (FAME analysis), isoprenoid quinones, protein profiles (e.g. MALDI-TOF), cytochrome composition, polyamines.	8	CO3, CO4	K2, K3, K4, K5
	<b>Nucleic acid-based techniques:</b> T-RFLP, G+C content (Tm and HPLC); 16S rRNA / 18S rRNA / ITS gene sequencing; phylogenetic analysis; DNA-DNA hybridization; DNA barcoding.	7	CO3, CO4	K2, K3, K4, K5
<b>Module 3:</b>	<b>Salient features of phylum, class and orders with representative examples:</b> Archaea; Eubacteria (bacteria, cyanobacteria, actinomycetes); Mycota; Protista (algae, protozoa, diatoms); viruses	15	CO3	K1, K2, K3
<b>Pedagogy:</b>	Lectures/tutorials/assignments/group discussion/seminars/ICT tools			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Barlow, A. (1992) The prokaryotes: A Handbook on the Biology of Bacteria: Ecophysiology, Isolation, Identification, Applications. (2<sup>nd</sup> Edition), Volume 1, Springer-Verlag. New York.</li> <li>Goodfellow, M. and Minnikin, D. E. (1985) Chemical Methods in Bacterial Systematics, The Society for Applied Bacteriology. Technical Series No. 20, Academic Press. London, Orlando.</li> </ol>			

	<ol style="list-style-type: none"> <li>3. Goodfellow, M., Mordarski, M. and Williams, S. T. (1983) The biology of the actinomycetes (1<sup>st</sup> Edition). Academic Press. London, Orlando.</li> <li>4. Kurtzman, C. P., Fell, J. W. and Boekhout, T. (2011) The Yeasts - A Taxonomic Study. (5<sup>th</sup> Edition). Elsevier.</li> <li>5. Norris, J. R. and Ribbons, D. W. (1971) Methods in Microbiology, Vol. 18 &amp; 19, Academic Press. New York.</li> <li>6. Prescott, L. M., Harley, J. P. and Klein, D.A. (2020) Microbiology. McGraw Hill, New York.</li> <li>7. Reddy, C. A. (2007) Methods for General and Molecular Microbiology. (3<sup>rd</sup> Edition). ASM Press. Washington.</li> <li>8. Sneath, A. H. P., Mair, S. N. and Sharpe, E. M. (2004) Bergey's Manual of Systematic Bacteriology. (2<sup>nd</sup> Edition). Vol. 2. Williams &amp; Wilkins Bacteriology Symposium, Series No 2, Academic Press, London/New York.</li> </ol>
<p><b>References/ Readings:</b></p>	<ol style="list-style-type: none"> <li>1. Ludwig, W. (2007). Nucleic acid techniques in bacterial systematics and identification. <i>International journal of food microbiology</i>, 120(3), 225-236. <a href="https://doi.org/10.1016/j.ijfoodmicro.2007.06.023">https://doi.org/10.1016/j.ijfoodmicro.2007.06.023</a></li> <li>2. Moore, E. R., Mihaylova, S. A., Vandamme, P., Krichevsky, M. I., &amp; Dijkshoorn, L. (2010). Microbial systematics and taxonomy: relevance for a microbial commons. <i>Research in microbiology</i>, 161(6), 430-438. <a href="https://doi.org/10.1016/j.resmic.2010.05.007">https://doi.org/10.1016/j.resmic.2010.05.007</a></li> <li>3. Prakash, O., Verma, M., Sharma, P., Kumar, M., Kumari, K., Singh, A., ... &amp; Lal, R. (2007). Polyphasic approach of bacterial classification—an overview of recent advances. <i>Indian Journal of Microbiology</i>, 47, <a href="https://doi.org/10.1007/s12088-007-0022-x">https://doi.org/10.1007/s12088-007-0022-x</a></li> <li>4. Sharma, R., Polkade, A. V., &amp; Shouche, Y. S. (2015). 'Species concept'in microbial taxonomy and systematics. <i>Current science</i>, 1804-1814. <a href="https://www.jstor.org/stable/24905604">https://www.jstor.org/stable/24905604</a></li> <li>5. Vandamme, P., Pot, B., Gillis, M., De Vos, P., Kersters, K., &amp; Swings, J. (1996). Polyphasic taxonomy, a consensus approach to bacterial systematics. <i>Microbiological reviews</i>, 60(2), <a href="https://doi.org/10.1128/mr.60.2.407-438.1996">https://doi.org/10.1128/mr.60.2.407-438.1996</a></li> </ol>
<p><b>Web Resources:</b></p>	<ol style="list-style-type: none"> <li>1. <a href="https://www.intechopen.com/chapters/46229">https://www.intechopen.com/chapters/46229</a></li> <li>2. <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC6560418/">https://pmc.ncbi.nlm.nih.gov/articles/PMC6560418/</a></li> <li>3. <a href="https://www.ncbi.nlm.nih.gov/books/NBK8406/">https://www.ncbi.nlm.nih.gov/books/NBK8406/</a></li> <li>4. <a href="https://egyankosh.ac.in/bitstream/123456789/93477/1/Unit-2.pdf">https://egyankosh.ac.in/bitstream/123456789/93477/1/Unit-2.pdf</a></li> </ol>

<b>Title of the Course</b>	Microbial Taxonomy and Systematics [P]
<b>Course Code</b>	MIC-5009
<b>Number of Credits</b>	1
<b>Theory/Practical</b>	Practical
<b>Level</b>	500
<b>Effective from AY</b>	2025-26
<b>New Course</b>	No
<b>Bridge Course/ Value added Course</b>	No
<b>Course for advanced learners</b>	No

<b>Pre-requisites for the Course:</b>	It is assumed that students should have a basic understanding of binomial nomenclature, the basis of classification systems and be familiar with the distinguishing features of different groups of microorganisms.			
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>		
	CO 1. Explain the taxonomic evolution of the microbial world and understand the Tools and techniques of taxonomy and systematics	PSO 1, PSO 2		
	CO 2. Categorise the microorganisms on the basis of their characteristics using standard rules of classification systems.	PSO 3, PSO 4		
	CO 3. Appraise the applications of taxonomic tools in identifying the microorganisms.	PSO 4		
	CO 4. Describe fungal diversity along with Classification.	PSO 2, PSO 4		
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>

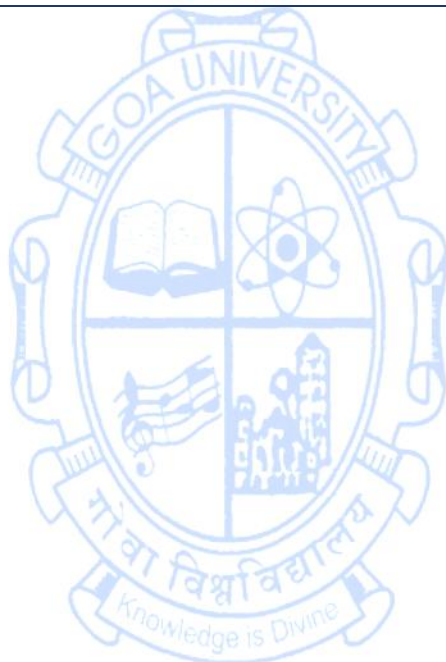
<b>Module 1:</b>	Morphological, physiological and biochemical characterization of bacteria.	<b>30</b>	CO1, CO2	K2
<b>Module 2:</b>	Chemotaxonomic analysis of cell wall amino acids.		CO 3	K2, K3
<b>Module 3:</b>	Characterization of actinomycetes ( <i>Streptomyces</i> sp.).		CO 3	K3, K4
<b>Module 4:</b>	Characterization of yeast ( <i>Saccharomyces cerevisiae</i> , <i>Schizosaccharomyces pombe</i> )		CO 2, CO 4	K3, K4
	Characterization of cyanobacteria.		CO 2, CO 3	K3, K4
	Phylogenetic analysis of bacterial 16S rRNA sequences – retrieval of sequences from standard databases, BLAST analysis, construction of phylogenetic tree using bioinformatics tools.		CO 2, CO 3	K5, K6
<b>Pedagogy:</b>	Hands-on experiments in the laboratory, video, online data			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Balows, A., Trüper H. G., Dworkin, M., Harder, W., &amp; Schleifer, K.-H. (2013). <i>The Prokaryotes: A Handbook on the Biology of Bacteria: Ecophysiology, Isolation, Identification, Applications</i>. Springer.</li> <li>Goodfellow, M., &amp; Minnikin, D. E. (1985). <i>Chemical methods in bacterial systematics</i> (Technical Series No. 20). Academic Press.</li> <li>Kurtzman, C. P., Fell, J. W., &amp; Boekhout, T. (Eds.). (2011). <i>The yeasts: A taxonomic study</i> (Vol. 2). Elsevier.</li> <li>Prescott, L. M., Harley, J. P., &amp; Klein, D. A. (2020). <i>Microbiology</i>. McGraw Hill, New York.</li> <li>Sneath, P. H. A., Mair, N. S., &amp; Sharpe, E. M. (2004). <i>Bergey's manual of systematic bacteriology</i>, Vol. II. Academic Press.</li> </ol>			
<b>Web Resources:</b>	<a href="http://pmc.ncbi.nlm.nih.gov">http://pmc.ncbi.nlm.nih.gov</a>			

<b>Title of the Course</b>	Industrial Microbiology [T]	
<b>Course Code</b>	MIC-5010	
<b>Number of Credits</b>	3	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	500	
<b>Effective from AY</b>	2025-26	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Basic knowledge about the types of microbial physiology and metabolism. Knowledge of microbial biochemistry, physiology, genetics, sterilization techniques and statistics.	
<b>Course Objectives:</b>	To introduce industrial applications of microorganisms, focusing on microbial processes involved in the quality production of pharmaceuticals, food and beverages, biofuels, and other biotechnological products using instrumentation. The course highlights strain improvement, process optimization, fermentation technology, and monitoring frameworks.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO1. Explain the fundamental principles and applications of industrial microbiology.	PSO1, PSO2
	CO2. Operate basic fermentation equipment and outline industrial fermentation processes.	PSO2, PSO3
	CO3. Identify and describe the microbial production of commercially important products.	PSO3, PSO6
	CO4. Analyze the strategies for microbial strain development and process optimization.	PSO4, PSO5

	CO5. Evaluate the importance of quality control and regulatory practices in microbial industries.		PSO5, PSO6, PSO7 and PSO8	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	1.1 History of Industrial Microbiology, fermentation processes, descriptive layout and components of fermentation process for extracellular and intracellular microbial products.	4	CO1	K1
	1.2 Microbial growth kinetics: Batch kinetics – Monod’s model (single substrate), deviations from Monod’s model, dual substrates – sequential utilization, multiple substrates – simultaneous utilization, substrate inhibition, product synthesis (primary and secondary metabolite), toxic inhibition, death constant.	5	CO2	K2
	1.3 Microbial growth kinetics: Fed-batch kinetics – fixed volume, variable volume and cyclic fedbatch, applications and examples of fed-batch systems. Continuous cultivation system – relationship between specific growth rate ( $\mu$ ) and dilution rate, multistage systems, feedback systems (internal and external feedback), applications and examples of continuous cultivation system; comparison between various cultivation systems.	6	CO3	K3
<b>Module 2:</b>	2.1 Optimization and modeling of fermentation process – single variable design, multivariate screening designs, critical factor analysis, optimization designs for two or more factor, singlet method; Metabolic and flux control analysis.	4	CO2	K2
	2.2 Bioreactor design and operation: classification of reactors; Ideal mixed v/s plug flow reactor; designing parameters for reactors (stirred tank reactor, airlift reactor, plug flow reactor), rheology of fermentation broth.	6	CO3	K3
	2.3 Bioreactor design and operation: gas-liquid mass transfer, heat transfer, analysis of dimension less parameters and their application (aeration number, power number and Reynold’s number; Scale-up of bioprocesses: parameters used in scale-up and problems associated with scale-up.	5	CO3, CO4	K4, K5

<b>Module 3:</b>	3.1 Solid substrate fermentation (SSF): Principles and application; Comparison between SSF and Submerged Fermentation (SmF), Bioreactor for SSF. Problems in fermentation process and handling (foam, contamination, strain degeneration, etc), Immobilized enzymes and cell systems.	4	CO1, CO2	K2, K3
	3.2 Fermentation monitoring and control: Common measurement and control systems (speed, temperature, gas, pH, Dissolved oxygen, foam, redox, air flow, weight, pressure, biomass), On-line and off-line analysis, Digital controllers, control algorithm, flow charting, incubation control, advanced fermentation control and computer-based automation of process.	5	CO3. CO4	K4
	3.3 Industrial scale Down-stream processing and product recovery: principle and general description of instrumentation, Recovery of particulates (cells and solid particles), recovery of intracellular products, primary isolation (extraction, sorption), precipitation, industrial processes for chromatography and fixed bed adsorption, membrane separations; Type Processes - Antibiotic (Penicillin including semi-synthetic), Ethanol.	6	CO5, CO6	K5
<b>Pedagogy:</b>	Lectures/tutorials/assignments/Group discussion/ seminar/ICT tools			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Atkinson, B., &amp; Mavituna, F. (1991). <i>Biochemical engineering and biotechnology handbook</i>. (2<sup>nd</sup> Ed) Stockton Press, New York .</li> <li>2. Casida, L. E. (2016). <i>Industrial microbiology</i>. (2<sup>nd</sup> Ed) New Age International Limited New Delhi.</li> <li>3. Demain, A. L., Davies, J. E., &amp; Atlas, R. M. (1999). <i>Manual of industrial microbiology and biotechnology</i>. (3<sup>rd</sup> Ed) ASM Press United States.</li> <li>4. Flickinger, M. C., &amp; Drew, S. W. (1999). <i>The encyclopedia of bioprocess technology: Fermentation, biocatalysis and bioseparation</i> (Vols. 1–5). John Wiley , United States.</li> <li>5. Prescott, L. M., Harley, J. P., &amp; Klein, D. A. (2020). <i>Microbiology</i> (9<sup>th</sup> Ed.). McGraw-Hill, New York.</li> <li>6. Stanbury, P. F., Whitaker, A., &amp; Hall, S. J. (2016). <i>Principles of fermentation technology</i> (2<sup>nd</sup> Ed.). Butterworth-Heinemann United Kingdom.</li> <li>7. Vogel, H. C., &amp; Todaro, C. M. (2014). <i>Fermentation and biochemical engineering handbook: Principles, process design and equipment</i>. (2<sup>nd</sup> Ed) William Andrew Publishing, United States.</li> </ol>			

<b>References/ Readings:</b>	1. Yadav, M., Sehwat, N., Sangwan, A., Kumar, S., Beniwal, V., & Singh, A. K. (2013). Artificial neural network (ANN): application in media optimization for industrial microbiology and comparison with response surface methodology (RSM). <i>Adv Appl Sci Res</i> , 4(4), 457-460.
<b>Web Resources:</b>	1. <a href="https://www.sciencedirect.com/science/article/pii/S1389172305704606">https://www.sciencedirect.com/science/article/pii/S1389172305704606</a> 2. <a href="https://www.sciencedirect.com/science/article/pii/S1389172305704606">https://www.sciencedirect.com/science/article/pii/S1389172305704606</a> 3. <a href="https://academic.oup.com/jambio/article-abstract/91/2/306/6724017">https://academic.oup.com/jambio/article-abstract/91/2/306/6724017</a>



<b>Title of the Course</b>	Industrial Microbiology [P]	
<b>Course Code</b>	MIC-5011	
<b>Number of Credits</b>	1	
<b>Theory/Practical</b>	Practical	
<b>Level</b>	500	
<b>Effective from AY</b>	2025-26	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Basic knowledge about the types of microbes and their products of industrial relevance. Knowledge of microbial biochemistry, physiology, genetics and statistics.	
<b>Course Objectives:</b>	Development of concepts in the processes, instruments, management, quality, etc. being used in the industries to produce the products using microorganisms. Students will learn the economics of the fermentation for the total cost of production.	
		<b>Mapped to PSO</b>
<b>Course Outcomes</b>	CO 1. Discuss management and control of the microbial processes in research and industrial settings.	PSO 3, PSO 4
	CO 2. Develop microbial processes in research and industrial settings.	PSO 4, PSO 5
	CO 3. Connect physiological principles with the industrial processes.	PSO 4, PSO 5
	CO 4. Evaluate quality of microbial product and process.	PSO 5, PSO 6

<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>1</b>	Designing of fermentor – stirred tank reactor.	<b>4</b>	CO1	K2
<b>2</b>	Fermentation kinetics – growth of E.coli/S.cerevisiae and determination of $\mu_{max}$ , $K_s$ , $Y_{x/s}$ , m.	<b>6</b>	CO2	K3
<b>3</b>	Rheology of substrate solutions.	<b>4</b>	CO3	K2, K3
<b>4</b>	Immobilization of microbial cells using alginate.	<b>2</b>	CO3	K3, K6
<b>5</b>	Baker's yeast – ISI/BSI quality assurance.	<b>14</b>	CO4	K5
<b>Pedagogy:</b>	Hands-on experiments in the laboratory, video, online data			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Reed, G. (Ed.). (2004). Prescott &amp; Dunn's industrial microbiology (4th ed.). CBS Publishers.</li> <li>2. Waites, M. J., Morgan, N. L., Rockey, J. S., &amp; Higton, G. (2001). Industrial microbiology: An Introduction. Wiley-Blackwell.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Atkinson, B., &amp; Mavituna, F. (1991). Biochemical engineering and biotechnology handbook. Stockton Press.</li> <li>2. Demain, A. L., Davies, J. E., &amp; Atlas, R. M. (1999). Manual of industrial microbiology and biotechnology. ASM Press.</li> <li>3. Flickinger, M. C., &amp; Drew, S. W. (Eds.). (1999). The Encyclopedia of Bioprocess Technology: Fermentation, Biocatalysis and Bioseparation (Vols. 1-5). John Wiley.</li> <li>4. Stanbury, P. F., Whitaker, A., &amp; Hall, S. J. (2016). Principles of Fermentation Technology. Butterworth-Heinemann Publishers.</li> <li>5. Vogel, H. C., &amp; Tadaro, C. M. (2014). Fermentation and Biochemical Engineering handbook: Principles, process design and equipment. William Andrew Publisher.</li> </ol>			
<b>Web Resources:</b>	<a href="http://microbenotes.com">http://microbenotes.com</a>			

<b>Title of the Course</b>	Molecular Biology [T]		
<b>Course Code</b>	MIC-5012		
<b>Number of Credits</b>	03		
<b>Theory/Practical</b>	Theory		
<b>Level</b>	500		
<b>Effective from AY</b>	2025-26		
<b>New Course</b>	No		
<b>Bridge Course/ Value added Course</b>	No		
<b>Course for advanced learners</b>	No		
<b>Pre-requisites for the Course:</b>	MIC-5002		
<b>Course Objectives:</b>	To enhance the comprehension of concepts in molecular biology.		
<b>Course Outcomes:</b>			<b>Mapped to PSO</b>
	CO 1. Classify genome and gene structure.		PSO1
	CO 2. Summarize the regulation of gene expression in both prokaryotes and eukaryotes.		PSO5
	CO 3. Explain DNA damage and repair.		PSO1
	CO 4. Connect genomics to expressed proteins		PSO4
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>

<b>Module 1</b>	<b>Chromosome architecture and eukaryotic DNA replication</b>	<b>04</b>	CO1	K1, K2
	<b>1.1 Nucleic acids, types of DNAs and DNA packaging</b>			
	Structure of DNA and RNA.			
	Types of DNA (A-DNA, B-DNA, Z-DNA and triplex DNA) and their structural characteristics.			
	DNA packaging in bacteria (nucleoid) and viruses.			
	<b>1.2 Chromosomes, genomes and their evolution</b>	<b>05</b>	CO1	K2, K4
	Fundamental functions of DNA.			
	Chromosomal DNA and its packaging in the chromatin fibre, chromatin organization.			
	Structural features (telomere, centromere and repetitive sequences) of chromosomes and their functions. Lampbrush and polytene chromosomes.			
	Evolution of genomes, paralogous and orthologous evolution of duplicated genes	<b>06</b>	CO1	K2, K3, K4
<b>1.3 DNA replication in eukaryotes</b>				
DNA replication in the context of the cell cycle; Structure and functions of eukaryotic DNA polymerases, functions of other enzymes (helicase, gyrase, topoisomerase, primase, ligase, telomerase); Steps involved in DNA replication; Similarities and differences between prokaryotic and eukaryotic DNA replication.	<b>08</b>	CO3	K2, K3, K4	
<b>DNA damage, repair and recombination</b>				
<b>2.1 DNA damage and repair mechanisms</b>				
Types of DNA damage: spontaneous and induced DNA damage.				
Mechanisms / pathways to remove damaged DNA: Excision repair, mismatch repair, recombination repair, SOS Repair, photoreactivation repair.	<b>07</b>	CO3	K2, K3,	
<b>2.2 Mechanisms of genetic recombination</b>				

	General and site-specific recombination.			K4
	Homologous recombination, Non-homologous end joining (NHEJ).			
	Synaptonemal complex, Bacterial RecBCD system and its stimulation of chi sequences.			
	Role of RecA / RAD51 in repair and recombination			
<b>Module 3</b>	<b>Gene expression and its regulation in prokaryotes and eukaryotes</b>	<b>05</b>	CO2	K1, K2, K4
	<b>3.1 The central dogma and RNA biology</b>			
	The central dogma concept, DNA to RNA to protein			
	The RNA world and the origin of life.			
	Structure and function of prokaryotic and eukaryotic RNA: Prokaryotic and eukaryotic mRNA, tRNA, rRNA and ribosomes, processing of eukaryotic hnRNA, snRNA.	<b>05</b>	CO2	K2, K3, K4
	<b>3.2 Gene expression and its regulation</b>			
	An overview of gene expression control, DNA binding motifs in gene regulatory proteins, genetic switches and their role in the control of gene expression, combinatorial gene control.			
	Post-transcriptional controls: Transcriptional attenuation, riboswitches, alternate splicing, RNA editing, RNA interference.	<b>05</b>	CO4	K3, K4, K5
<b>3.3 Protein synthesis, processing, and localization</b>				
Synthesis and processing of proteins: The genetic code, aminoacylation of tRNA, mechanism of protein synthesis, translational proof-reading, translational inhibitors.				
Protein folding, post-translational modifications of proteins, leader sequences, protein localization and secretion.				

<b>Pedagogy:</b>	Lectures, tutorials, assignments, seminars, group discussions
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K. and Walter, P. (2022). <i>Molecular Biology of the Cell</i>, W. W. Norton &amp; Company, New York.</li> <li>2. Darnell, J. E., Lodish, H. F. and Baltimore, D. (2021). <i>Molecular Cell Biology</i>, W. H. Freeman, New York.</li> <li>3. Gardner, E. J., Simmons, M. J. and Snustad, D. P. (2011). <i>Principles of Genetics</i>, John Wiley &amp; Sons, Hoboken, NJ.</li> <li>4. Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. (2018). <i>Lewin's Genes XII</i>, Jones &amp; Bartlett Learning, Burlington, MA.</li> <li>5. Watson, J. D. (2024). <i>Molecular Biology of the Gene</i>, Pearson/Benjamin Cummings, New York.</li> </ol>
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Chatterjee, N., &amp; Walker, G. C. (2017). Mechanisms of DNA damage, repair, and mutagenesis. <i>Environmental and Molecular Mutagenesis</i>, 58(5), 235–263. <a href="https://doi.org/10.1002/em.22087">https://doi.org/10.1002/em.22087</a></li> <li>2. Cramer, P. (2019). Organization and regulation of gene transcription. <i>Nature</i>, 573, 45–54. <a href="https://doi.org/10.1038/s41586-019-1517-4">https://doi.org/10.1038/s41586-019-1517-4</a></li> <li>3. Misteli, T. (2020). The self-organizing genome: Principles of genome architecture and function. <i>Cell</i>, 183(1), 28–45. <a href="https://doi.org/10.1016/j.cell.2020.09.014">https://doi.org/10.1016/j.cell.2020.09.014</a></li> <li>4. Oudelaar, A. M., &amp; Higgs, D. R. (2021). The relationship between genome structure and function. <i>Nature Reviews Genetics</i>, 22(3), 154–168. <a href="https://doi.org/10.1038/s41576-020-00304-4">https://doi.org/10.1038/s41576-020-00304-4</a></li> <li>5. Ventura, S. (2015). Protein misfolding diseases. <i>Future Science OA</i>, 1(2), FSO38. <a href="https://doi.org/10.4155/fso.15.38">https://doi.org/10.4155/fso.15.38</a></li> <li>6. Zhao, B. S., Roundtree, I. A., &amp; He, C. (2017). Post-transcriptional gene regulation by mRNA modifications. <i>Nature Reviews Molecular Cell Biology</i>, 18, 31–42. <a href="https://doi.org/10.1038/nrm.2016.132">https://doi.org/10.1038/nrm.2016.132</a></li> </ol>
<b>Web Resources:</b>	<ol style="list-style-type: none"> <li>1. <a href="https://dnalc.cshl.edu/">https://dnalc.cshl.edu/</a></li> <li>2. <a href="https://www.biointeractive.org/">https://www.biointeractive.org/</a></li> </ol>

<b>Title of the Course</b>	Molecular Biology [P]		
<b>Course Code</b>	MIC- 5013		
<b>Number of Credits</b>	1		
<b>Theory/Practical</b>	Practical		
<b>Level</b>	400		
<b>Effective from AY</b>	2025-2026		
<b>New Course</b>	No		
<b>Bridge Course/ Value added Course</b>	No		
<b>Course for advanced learners</b>	No		
<b>Pre-requisites for the Course:</b>	Nil		
<b>Course Objectives:</b>	This course develops concepts in molecular biology: DNA packaging, DNA damage and repair, gene structure, expression and regulation in both prokaryotes and eukaryotes		
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>	
	CO 1. Identify and extract genomic DNA and mRNA of eukaryotes	PSO1, PSO3, PSO4	
	CO 2. Construct cDNA	PSO3, PSO4, PSO5	
	CO 3. Compare gene and its expression	PSO3, PSO4	
	CO 4. Evaluate amplified DNA product	PSO4, PSO5	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>
			<b>Cognitive Level</b>

<b>1.</b>	Isolation of genomic DNA of eukaryotic microorganisms, estimation of quantity and purity of DNA by spectrophotometry, and agarose gel electrophoresis.	<b>10</b>	CO1	K3, K4, K5
<b>2.</b>	Recovery of genomic DNA from agarose gel.	<b>4</b>	CO1	K3, K4
<b>3.</b>	Extraction of mRNA / total RNA.	<b>4</b>	CO1	K3, K4
<b>4.</b>	cDNA synthesis from mRNA.	<b>6</b>	CO2	K3, K4, K5
<b>5.</b>	PCR amplification of a specific gene using genomic DNA as a template and agarose gel analysis of PCR product to determine amplicon size.	<b>6</b>	CO4	K3, K4, K5
<b>Pedagogy:</b>	Hands-on experiments in the laboratory, video, online data			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Darnell, J. E., Lodish, H. F. and Baltimore, D. (1990), Molecular Cell Biology, Scientific American Books, Spektrum Akademischer Verlag.</li> <li>2. Davis, L. G., Dibner, M. D. and Battey, J. F. (1986), Basic Methods in Molecular Biology, Elsevier.</li> <li>3. Gardner, E. J., Simmons, M. J. and Snustad. (2006), D. P. Principles of Genetics, John Wiley &amp; Sons.</li> <li>4. Krebs, J.E., Krebs J.E., Lewin B., Goldstein E.S. and Kilpatrick, S.T. (2018), Lewin's Genes XII, Jones and Bartlett Publishers.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Darnell, J. E., Lodish, H. F. and Baltimore, D. (1990), Molecular Cell Biology, Scientific American Books, Spektrum Akademischer Verlag.</li> <li>2. Gerhardt, P. (1994), Methods for General and Molecular Bacteriology, Elsevier.</li> <li>3. Green, M. R. and Sambrook, J. (2014), Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory, New York.</li> <li>4. Malacinski, G.M. (2008), Freifelder's, Essentials of Molecular Biology, Narosa Book Distributors Private Limited.</li> <li>5. Tamarin, R. H. (2017), Principles of Genetics, McGraw-Hill Higher Education.</li> <li>6. Twyman, R. M. and Wisden, W. (1998), Advanced Molecular Biology: A Concise Reference, Garland Science.</li> <li>7. Watson, J. D. (2007), Molecular Biology of the Gene, Pearson/Benjamin Cummings.</li> </ol>			
<b>Web Resources:</b>	<a href="https://bmcbiotechnol.biomedcentral.com/articles/10.1186/s12896-018-0421-6">https://bmcbiotechnol.biomedcentral.com/articles/10.1186/s12896-018-0421-6</a>			

<b>Title of the Course</b>	Archaea - Ecology, Physiology, Biochemistry and Genetics	
<b>Course Code</b>	MIC-5014	
<b>Number of Credits</b>	3	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	500	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	This course gives the understanding of the ecology, diversity, cell structure, physiology and genetics of Archaea.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Describe the ecology, physiology and biochemistry of the domain Archaea.	PSO 1
	CO 2. Integrate the metabolism and physiology of Archaea.	PSO 1, PSO 2
	CO 3. Relate the Principle of Archaeal Genetics.	PSO 1, PSO 2, PSO 3, PSO 4, PSO 5

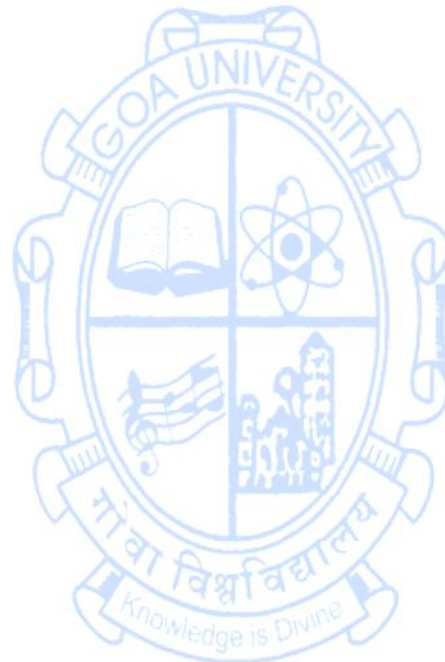
	CO 4. Appraise the application of Archaea and archaeal bioactive compounds.		PSO 1, PSO 2, PSO 3, PSO 4, PSO 5, PSO 6, PSO 7, PSO 8
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b> <b>Cognitive Level</b>
<b>Module 1:</b>	Ecology, Taxonomy and Significance of the Domain Archaea	<b>2</b>	CO1, CO2 K1, K2, K3
	1.1 Evolution of the Domain Archaea: Three domains of life – Archaea, Eubacteria and Eukarya. a) Carl Woese classification of archaea based on 16S rRNA analysis. b) Similarities and dissimilarities - archaea, eubacteria and eukaryotes. c) Uniqueness of archaea versus other extremophilic microorganisms.		
	1.2 Ecology and Diversity of Archaea a) Ecology and Global niches: Deep Sea, Hydrothermal vent, Dead Sea, solar salterns, geothermal vents, solfataras, Antarctica, soda lake, alkaline hot springs, marshy land. b) Strategies to cultivate, preserve and maintain Thermophilic and Halophilic Archaea. c) Studies of unculturable archaea by metagenomics.	<b>3</b>	CO1, CO2, CO3 K1, K2, K3
	1.3 Archaeal Taxonomy: Nutrition, growth Characteristics and physiological versatility, Stress response of Major Archaeal Physiological Groups a) Phyla Euryarchaeota : (i) Methanogens ( <i>Methanobacterium thermoautotrophicum</i> ), (ii) Haloarchaea ( <i>Halobacterium halobium</i> ) and (iii) Thermophiles ( <i>Thermoplasma acidophilum</i> ); (iv) Psychrophilic archaea ( <i>Methanogenium frigidum</i> ) b) Phyla Crenarchaeota : (i) <i>Sulfolobus</i> and (ii) <i>Thermoproteus</i> c) Phyla Thaumarchaeota : Archaeal ammonia oxidizers d) Phyla Korarchaeota	<b>3</b>	CO1, CO2 K1, K2, K3

	<p>e) Phyla Thermoproteota : thermoacidophilic (<i>Sulfolobus acidocaldarius</i>), <i>Ignicoccus hospitalis</i></p> <p>f) Phyla Nanoarchaeota: <i>Nanoarchaeum equitans</i></p>			
	<p>1.4 Cell structure and architecture of Archaea:</p> <p>a) Shape Arrangement and size : <i>Haloquadratum walsbyi</i></p> <p>b) Comparison Between Archaeal and Bacterial Cells</p> <p>c) Cellular organization: cell morphotypes, cell envelopes 4 Envelopes; membrane lipids and cell wall, ribosomes, histones nucleosomes appendages -pili, flagella, cannulae, hami.</p> <p>d) Novel bio-molecules: Glycerol diether moieties and macrocyclic lipid, enzymes, co-enzymes: methanopterin, formaldehyde activation factor, Component B, Coenzyme M, F420, F430, corrinoids.</p>	4	CO1, CO2, CO3,	K1, K2, K3
	<p>1.5 Significance of Archaea in Biotechnology and Biogeochemical cycling:</p> <p>a) <i>Pyrococcus furiosus</i>- Pfu Polymerase in Molecular studies</p> <p>b) <i>Halobacterium salinarum</i> – Bacteriorhodopsin</p> <p>c) <i>Thermococcus gammatolerans</i> - To improve DNA repair and reduce cellular aging</p> <p>d) <i>Methanosarcina</i> – Methane production</p>	3	CO1, CO2, CO3, CO4	K1, K2, K3, K4, K5, K6
<b>Module 2:</b>	Metabolism and Energetics of Archaea	5	CO2,CO4	K2, K3, K4
	<p>2.1. Modified anabolic pathways:</p> <p>a) Gluconeogenesis</p> <p>b) Lipid biosynthesis</p> <p>c) Methanogenesis: from CO<sub>2</sub> and methanol</p> <p>d) Acetoclastic reactions in <i>Methanosarcina</i> - H<sub>2</sub> dependent and H<sub>2</sub> independent; and Methanotherix</p> <p>e) Carbon dioxide reduction pathways: 3-hydroxypropionate pathway, and reverse Krebs cycle</p>			

	f) Bacterioruberin pathway			
	2.2. Modified catabolic pathways: a) EMP b) ED: Semiphosphorylative and Nonphosphorylative ED pathway c) Chemolithoautotrophy: S oxidation	5	CO2, CO4	K2, K3, K4
	2.3. Bioenergetics: ATP synthesis (i) respiration-driven : Anaerobic a) light-driven:bacteriorhodopsin b) chloride-driven: halorhodopsin c) cation-driven.	5	CO2, CO4	K2, K3, K4
<b>Module 3:</b>	Genome of Archaea	5	CO3 CO4	K2, K3, K4, K5, K6
	3.1 Size of genome, G + C content, archaeal histones (Sul7d, MC1), chaperonins and heat shock proteins in archaea, introns in archaea, archaeal RNA polymerases, reverse DNA gyrase.			
	3.2 DNA replication, transcription and translation in archaea. Plasmids, transposons and insertion elements, AT-rich-islands, Modifications in tRNA and rRNA structure. Novel 7S rRNA.			
	3.3 Gene organization in Archaea: Operons (fdh, his and mcr). DNA repair in archaea.			
<b>Pedagogy:</b>	<b>Lectures/tutorials/assignments</b>			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Barker, D. M., (2010) Archaea: Salt-lovers, Methane-makers, Thermophiles and Other Archaeans, Crabtree Publishing Company. New York</li> <li>2. Blum, P., (2008) Archaea: New Models for Prokaryotic Biology, Caister Academic Press. United Kingdom</li> <li>3. Boone, D. R. and Castenholz, R. W., (2011) Bergey's Manual of Systematic Bacteriology: The Archaea and The Deeply Branching and Phototrophic Bacteria, Springer Science and Business Media. Berlin and Heidelberg, Germany</li> </ol>			

	<ol style="list-style-type: none"> <li>4. Cavicchioli, R., (2007) <i>Archaea: Molecular and Cellular Biology</i>, ASM Press. Washington, D.C., United States</li> <li>5. Corcelli, A. and Lobasso, S., (2006) <i>Characterization of Lipids of Halophilic Archaea</i>. <i>Methods in Microbiology</i>, 35: 585-613. London</li> <li>6. Garrett, R. A. and Hans-Peter, K., (2008) <i>Archaea: Evolution, Physiology and Molecular Biology</i>, John Wiley and Sons. New Jersey, USA</li> <li>7. Howland, J. L., (2000) <i>The Surprising Archaea: Discovering Another Domain of Life</i>, Oxford University Press. England</li> <li>8. Munn, C., (2011) <i>Marine Microbiology: Ecology and Applications</i>, Garland Science, Taylor and Francis Group, New York</li> <li>9. Rainey, F., Kämpfer, P., Trujillo, M., Chun, J., DeVos, P., Hedlund, B., &amp; Dedysh, S. (2015). <i>Bergey's manual of systematics of archaea and bacteria</i> (Vol. 410). W. B. Whitman (Ed.). Hoboken, NJ: Wiley. New Jersey, USA</li> <li>10. Garrett, R. A., &amp; Klenk, H. P. (Eds.). (2008). <i>Archaea: evolution, physiology, and molecular biology</i>. John Wiley &amp; Sons. New Jersey, USA</li> </ol>
<p><b>References/ Readings:</b></p>	<ol style="list-style-type: none"> <li>1. Rothe, O., &amp; Thomm, M. (2000). A simplified method for the cultivation of extreme anaerobic Archaea based on the use of sodium sulfite as reducing agent. <i>Extremophiles</i>, 4, 247-252.</li> <li>2. Woese, C. R., &amp; Fox, G. E. (1977). Phylogenetic structure of the prokaryotic domain: the primary kingdoms. <i>Proceedings of the National Academy of Sciences</i>, 74(11), 5088-5090.</li> <li>3. Leigh, J. A., Albers, S. V., Atomi, H., &amp; Allers, T. (2011). Model organisms for genetics in the domain Archaea: methanogens, halophiles, Thermococcales and Sulfolobales. <i>FEMS microbiology reviews</i>, 35(4), 577-608.</li> <li>4. Adam, P. S., Borrel, G., Brochier-Armanet, C., &amp; Gribaldo, S. (2017). The growing tree of Archaea: new perspectives on their diversity, evolution and ecology. <i>The ISME journal</i>, 11(11), 2407-2425.</li> <li>5. van Wolferen, M., Pulschen, A. A., Baum, B., Gribaldo, S., &amp; Albers, S. V. (2022). The cell biology of archaea. <i>Nature microbiology</i>, 7(11), 1744-1755.</li> <li>6. Albers, S. V., &amp; Meyer, B. H. (2011). The archaeal cell envelope. <i>Nature Reviews Microbiology</i>, 9(6), 414-426.</li> <li>7. Pfeifer, K., Ergal, I., Koller, M., Basen, M., Schuster, B., &amp; Rittmann, S. K. M. (2021). Archaea biotechnology. <i>Biotechnology Advances</i>, 47, 107668.</li> <li>8. Sun, Y., Liu, Y., Pan, J., Wang, F., &amp; Li, M. (2020). Perspectives on cultivation strategies of archaea. <i>Microbial ecology</i>, 79, 770-784.</li> <li>9. Baker, B. J., De Anda, V., Seitz, K. W., Dombrowski, N., Santoro, A. E., &amp; Lloyd, K. G. (2020). Diversity, ecology and evolution of Archaea. <i>Nature microbiology</i>, 5(7), 887-900.</li> </ol>
<p><b>Web Resources:</b></p>	<ol style="list-style-type: none"> <li>1. <a href="https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2021.827229/full">https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2021.827229/full</a></li> </ol>

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|  | <ol style="list-style-type: none"><li>2. <a href="https://www.ncbi.nlm.nih.gov/books/NBK579933/">https://www.ncbi.nlm.nih.gov/books/NBK579933/</a></li><li>3. <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC7613921/">https://pmc.ncbi.nlm.nih.gov/articles/PMC7613921/</a></li><li>4. <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC9855744/">https://pmc.ncbi.nlm.nih.gov/articles/PMC9855744/</a></li><li>5. <a href="https://pubmed.ncbi.nlm.nih.gov/16806054/">https://pubmed.ncbi.nlm.nih.gov/16806054/</a></li></ol> |
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<b>Title of the Course</b>	Archaea - Ecology, Physiology, Biochemistry and Genetics [P]		
<b>Course Code</b>	MIC-5015		
<b>Number of Credits</b>	01		
<b>Theory/Practical</b>	Practical		
<b>Level</b>	500		
<b>Effective from AY</b>	2025-2026		
<b>New Course</b>	No		
<b>Bridge Course/ Value added Course</b>	No		
<b>Course for advanced learners</b>	No		
<b>Pre-requisites for the Course:</b>	Nil		
<b>Course Objectives:</b>	To introduce the methods in sampling and isolation of archaea from different niches; identification of archaea and study of archaeal bio-molecules.		
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>	
	CO 1. Define the conditions for isolation and maintenance of Archaea.	PSO1, PSO3, PSO4, PSO5	
	CO 2. Classify the archaea using chemotaxonomy.	PSO1, PSO3, PSO4, PSO5	
	CO 3. Identify the archaeal isolates.	PSO1, PSO3, PSO4, PSO5	
	CO 4. Analyse the archaea for bioactive molecules.	PSO1, PSO2, PSO3, PSO4, PSO5, PSO8	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>
			<b>Cognitive Level</b>

	<ol style="list-style-type: none"> <li>1. Isolation and culturing of halophilic archaea. 06</li> <li>2. Identification of the isolates. 20 <ul style="list-style-type: none"> <li>• Biochemical tests for characterization of the halophilic archaea.</li> <li>• Extraction of archaeal pigment and characterization using UV-Vis spectroscopy.</li> <li>• Cellular lipids - Extraction and chromatographic resolution of lipids.</li> </ul> </li> <li>3. Screening for hydrolytic enzymes. 04</li> </ol>	06 20 04	CO1 CO2, CO3 CO4	K1 K2, K3 K4
<b>Pedagogy:</b>	Hands-on experiments in the laboratory, video, online data			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Barker, D. M. (2010). Archaea: Salt-lovers, Methane-makers, Thermophiles and Other Archaeans (A Class of Their Own). Crabtree Publishing Company, New York.</li> <li>2. Blum, P. (2008). Archaea: New Models for Prokaryotic Biology. Caister Academic Press, UK.</li> <li>3. Boone, D. R., and Castenholz, R. W. (2011). Bergey's Manual of Systematic Bacteriology: Volume One: The Archaea and the Deeply Branching and Phototrophic Bacteria, 2<sup>nd</sup> ed. Springer-Verlag New York Inc, New York.</li> <li>4. Cavicchioli, R. (2007). Archaea: Molecular and Cellular Biology, American Society for Microbiology Press, Washington, D.C.</li> <li>5. Garrett, R. A. and Hans-Peter, K. (2008). Archaea: Evolution, Physiology and Molecular Biology, John Wiley and Sons, England.</li> <li>6. Howland, J. L. (2000). The Surprising Archaea: Discovering Another Domain of Life, Oxford University Press, USA.</li> <li>7. Munn, C. (2011). Marine Microbiology: Ecology and Applications, Third edition. CRC Press, Taylor &amp; Francis Group, UK.</li> </ol>			
<b>References/ Readings:</b>	<ol style="list-style-type: none"> <li>1. Corcelli, A., and Lobasso, S. (2006). Characterization of Lipids of Halophilic Archaea. Methods in Microbiology, 35: 585-613.</li> <li>2. Rothe, O., and Thomm, M. A. (2000). Simplified method for the cultivation of extreme anaerobic archaea based on the use of sodium sulfite as reducing agent, Extremophiles. 4: 247-252.</li> <li>3. Woese, C. R., and Fox, G. E. (1977). Phylogenetic structure of the prokaryotic domain: the primary kingdoms. Proc Natl Acad Sci USA. 74: 5088–5090.</li> </ol>			
<b>Web Resources:</b>	<a href="https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2020.554927/full">https://www.frontiersin.org/journals/microbiology/articles/10.3389/fmicb.2020.554927/full</a> <a href="https://pmc.ncbi.nlm.nih.gov/articles/PMC11988811/">https://pmc.ncbi.nlm.nih.gov/articles/PMC11988811/</a>			

### Discipline Specific Elective Courses

<b>Title of the Course</b>	Agriculture Microbiology [T]	
<b>Course Code</b>	MIC-5205	
<b>Number of Credits</b>	3	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-26	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	Yes	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	The course deals with the information about Inter-relationship of soil and microorganisms, different groups of beneficial microorganisms in agriculture, microbes as biofertilizer, plant pathogen and biocontrol agent	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Recognition of the soil chemistry and its significance	PSO1, PSO2
	CO 2. Correlation of the biochemical processes of microbes with ecology	PSO1, PSO2, PSO3
	CO 3. Application of microorganisms in plant growth promotion	PSO1, PSO2, PSO3, PSO4, PSO5, PSO6, PSO7, PSO8

	CO 4. Analyzing the role of microorganisms as plant pathogens		PSO1, PSO2, PSO4, PSO5 PSO7, PSO8	
	CO 5. Formulating strategies for integrated management of pests and diseases		PSO1, PSO2, PSO3, PSO4, PSO5, PSO6, PSO7, PSO8	
<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Soil Microbiology			
	1.1 Microbial ecology	<b>05</b>	CO1, CO2	K1, K2
	Terrestrial Ecosystem, Pyramids and Econiches. 1.1 Soil Biogeochemistry: Types of soil, soil Profile, Physico-Chemical (abiotic) and biotic characteristics.			
	1.2 Factors influencing microbial survival and establishment of inoculants.	<b>05</b>	CO1, CO2	K1, K2
	Significance of microbial metabolism/enzymes on soil chemistry (nutrient cycling) & humus formation (humic and fulvic acids), Manure and compost as a soil amendment.			
	1.3 Plant and soil Microbiology	<b>05</b>	CO1, CO2, CO3	K2, K3
	Microbiology of the above and below ground parts of the plant (Phytosphere; Rhizosphere and Rhizoplane Microflora, phyllosphere, spermosphere)			
<b>Module 2:</b>	Plant-Microbe interactions (beneficial)			
	2.1 Plant growth promoting bacteria as biofertilizers Direct Mechanisms	<b>03</b>	CO2, CO3	K2, K3, K4
	Nutrient acquisition (nitrogen fixation, phosphate, Zinc, Potassium mobilization, siderophores, plant growth promoting hormones-Auxins, ACC Deaminase) Indirect Mechanisms: ISR, disease suppression			
	2.2 Mycorrhiza	<b>02</b>	CO2, CO3	
Ectomycorrhiza, Endomycorrhiza, VAM structure & significance.				

	2.3 Nitrogen Fixing Microbes			
	Free living nitrogen ( <i>Azotobacter</i> , <i>Azospirillum</i> ), associative ( <i>Cyanobacteria</i> , <i>Anabaena azollae</i> ) and symbiotic ( <i>Frankia</i> , <i>Rhizobium</i> ), Biochemistry and Genetics of Nitrogen fixation with reference to symbiotic and non symbiotic nitrogen fixers Significance of <i>nif</i> H, D, K, A, L, nod, nodulin and fix genes in the process of microbial nitrogen fixation.	05	CO2, CO3	K2, K3, K4
	2.4 Microbial Pesticides			
	Biocontrol agents for agriculturally important crop plants-Development and their significance; Source Organisms: Bacteria- <i>Bacillus thuringiensis</i> , Bt based commercial products, other Bacilli producing pesticides; Fungi— <i>Beauveria bassiana</i> , <i>Metarhizium anisopliae</i> , <i>Trichoderma</i> , Viruses-Baculoviruses for insect pest control.	05	CO2, CO5	K3, K4, K5, K6
<b>Module 3:</b>	Plant-Microbe interactions (Harmful)			
	3.1 Plant Pathogens and Genetic basis of pathogenesis	08	CO4	K2, K3, K4, K5
	Causative agents (bacteria, fungi, algae, virus, nematodes), pathogenesis, symptoms, control of common pathogens,.			
	3.2 Plant Defense Response			
	Phytoalexins and their induction; Plant defense responses or mechanisms of control (anatomical changes and biochemical synthesis of toxins, alkaloids and other biocontrol molecules).	02	CO4, CO5	K1, K2, K3, K4
	3.3 Other means of pathogen control			
	Application of Viral proteins in controlling viral diseases; Antisense RNA technology in disease control; Mycoviruses acting against fungal plant pathogens; Integrated pest management, post harvest management, agripreneurship development (steps for starting small industry)	05	CO4, CO5	K3, K4, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments			

<p><b>Texts:</b></p>	<ol style="list-style-type: none"> <li>1. Agrios G.N. (2005) Plant Pathology, Elsevier Academic Press, San Diego.</li> <li>2. Alexander, M. (1978) Introduction to Soil Microbiology, John Wiley and Sons, New York</li> <li>3. Bilgrami K. S. (1989) Plant Microbe Interactions: <i>Proceedings of Focal Theme Symposium, Indian Science Congress Association</i>, Narendra Publishing House, India</li> <li>4. Carr, N. G., &amp; Whitton, B. A. (Eds.). (1973). <i>The biology of blue-green algae</i> (Vol. 9). University of California Press, California</li> <li>5. Dadarwal, K. R. (1997) Biotechnological Approaches in Soil microorganisms for sustainable crop production, Scientific Publishers, India</li> <li>6. Kumar, H. D., (2004) Modern Concepts of Microbiology, Vikas Publishing House Pvt. Ltd. India</li> <li>7. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H. and Stahl, D. A. (2019) Brock Biology of Microorganisms, Fifteenth edition, Pearson Education Limited.</li> <li>8. Lugtenberg, B. (2016). <i>Principles of plant-microbe interactions</i>. No. 11912, Springer International Publishing</li> <li>9. Mahanta, K. C. (1969) Fundamentals of Agricultural Microbiology, Oxford &amp; IBH Publishers, India</li> <li>10. Subba Rao, N.S. (2017) Biofertilizers in Agriculture and Forestry, Medtech, Scientific International Pvt. Ltd. India</li> </ol>
<p><b>References/ Readings:</b></p>	<ol style="list-style-type: none"> <li>1. Upadhyay, R., Saini, R., Shukla, P. K., &amp; Tiwari, K. N. (2025). Role of secondary metabolites in plant defense mechanisms: A molecular and biotechnological insights. <i>Phytochemistry Reviews</i>, 24(1), 953-983.</li> <li>2. Mazid, M., Khan, T. A., &amp; Mohammad, F. (2011). Role of secondary metabolites in defense mechanisms of plants.</li> <li>3. Green, E. R., &amp; Mecsas, J. (2016). Bacterial secretion systems: an overview. <i>Virulence mechanisms of bacterial pathogens</i>, 213-239.</li> <li>4. Lomovatskaya, L. A., &amp; Romanenko, A. S. (2020). Secretion systems of bacterial phytopathogens and mutualists. <i>Applied biochemistry and microbiology</i>, 56, 115-129.</li> </ol>

<b>Title of the Course</b>	Agriculture Microbiology [P]	
<b>Course Code</b>	MIC-5206	
<b>Number of Credits</b>	1	
<b>Theory/Practical</b>	Practical	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-26	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	To assess the diverse parameters influencing soil health, and to study plant growth promoters and plant pathogens.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Appreciate and understand different soils and their microbes	PSO1, PSO2, PSO3
	CO 2. Isolate microorganisms for plant growth promotion.	PSO3, PSO4
	CO 3. Correlate biochemical processes of microbes to soil ecology.	PSO1, PSO2, PSO3, PSO4
	CO 4. Formulate biofertilizers for agricultural applications.	PSO3, PSO4, PSO5, PSO6
CO 5. Identify and classify microbial diseases of plants.	PSO3, PSO4, PSO7	

CO 6. Learn independent composting for households		PSO6, PSO8		
Content:		No of hours	Mapped to CO	Cognitive Level
<b>Module 1:</b>	Isolation of plant growth promoting bacteria from rhizosphere and screening for phosphate/zinc solubilisation, IAA production, K mobilisation, siderophore activity and seedling vigour test.	10	CO1, CO2, CO3	K2, K4, K5
<b>Module 2:</b>	Detection of microbial enzymes – amylase, phosphatase, lipase, protease, catalase, urease from various soils such as sandy soil and garden soil.	5	CO3	K2, K3, K4, K5
<b>Module 3:</b>	Isolation of microbial plant pathogen(s)-bacterial/fungal.	7	CO5	K2, K3, K4, K5
<b>Module 4:</b>	Preparation of biofertilizer using cyanobacteria, or composting methodology demonstration.	8	CO4, CO6	K2, K3, K4, K5, K6
<b>Pedagogy:</b>	Hands-on experiments in the laboratory, videos, online data			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Agrios G.N., (2004) Plant Pathology, (5<sup>th</sup> Edition) Academic Press, San Diego.</li> <li>2. Alexander, M., (1977) Introduction to Soil Microbiology, (2<sup>nd</sup> Edition) John Wiley Eastern Limited, New Delhi.</li> <li>3. Bilgrami K. S., (1987) Plant Microbe Interactions, Proceedings of Focal Theme Symposium, Indian Science Congress Association, Narendra Publishing House, Delhi.</li> <li>4. Carr, N. G. and Whitton, B. A., (1973) The Biology of Blue-green algae. (1<sup>st</sup> Edition) University of California Press, Berkeley.</li> <li>5. Dadarwal, K. R., (1997) Biotechnological Approaches in Soil microorganisms for sustainable crop production. (1<sup>st</sup> Edition) Scientific Publishers, Jodhpur.</li> <li>6. Kumar, H. D., (2004) Modern Concepts of Microbiology, (2<sup>nd</sup> Edition) Vikas Publishing House Pvt. Ltd, New Delhi.</li> <li>7. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H. and Stahl, D. A., (2017) Brock Biology of Microorganisms, (15<sup>th</sup> Edition) Pearson Education Limited, London.</li> <li>8. Mahanta, K. C.,(1969) Fundamentals of Agricultural Microbiology. (1<sup>st</sup> Edition) Oxford &amp; IBH Publishers, New Delhi.</li> <li>9. Somani, L.L.,(1987) Biofertilizers In Indian Agriculture. (1<sup>st</sup> Edition) Concept Publishing Company, New Delhi.</li> </ol>			

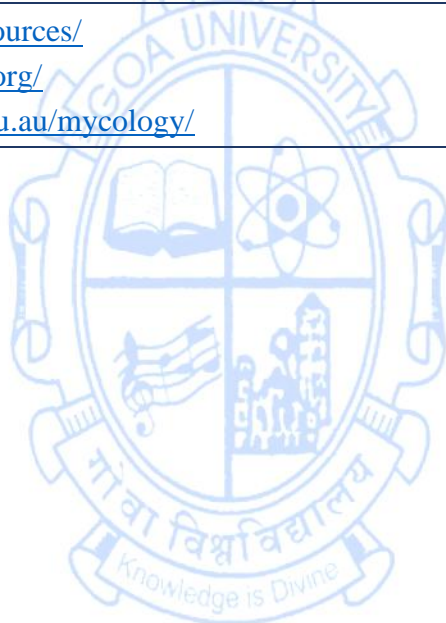
	<p>10. Subba Rao, N.S., (2017) Biofertilizers in Agriculture and Forestry, (3<sup>rd</sup> Edition) International Science Publishers, New York.</p> <p>11. Subba Rao, N. S., (1982) Advances in Agricultural Microbiology. (1<sup>st</sup> Edition) Oxford &amp; IBH Publishers, New Delhi.</p> <p>12. Veeresh, G. K. and Rajagopal, D., (1988) Applied Soil Biology and Ecology, (2<sup>nd</sup> Edition) Oxford &amp; IBH Publishing Company Pvt. Limited, New Delhi.</p>
<b>References/ Readings:</b>	<p>1. Yogranjan, P.K., (2020) Essentials of Agricultural Microbiology, (1<sup>st</sup> Edition) IP Innovative Publication Pvt. Ltd, Delhi.</p> <p>2. Aneja. K.R., (2017) Fundamental Agricultural Microbiology. (1<sup>st</sup> Edition) New Age International Publishers, New Delhi.</p>
<b>Web Resources:</b>	<p><a href="https://doi.org/10.1007/s10295-010-0866-7">https://doi.org/10.1007/s10295-010-0866-7</a></p> <p><a href="https://annalsmicrobiology.biomedcentral.com/articles/10.1007/s13213-010-0117-1">https://annalsmicrobiology.biomedcentral.com/articles/10.1007/s13213-010-0117-1</a></p>

<b>Title of the Course</b>	Mycology [T]	
<b>Course Code</b>	MIC-5207	
<b>Number of Credits</b>	3	
<b>Theory/Practical</b>	Theory	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-26	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	This course deals with classification and identification of fungi, fungal diversity, genetics and their applications.	
<b>Course Outcomes:</b>		<b>Mapped to PSO</b>
	CO 1. Describe fungal diversity along with Classification. Explain the distribution of fungi in different ecosystems.	PSO 1, PSO 2
	CO 2. Concept of recombinant technology with special emphasis in fungal system, Identify the fungal isolates.	PSO 1, PSO 2, PSO 4, PSO 5
	CO 3. Identify and explore the fungal isolates for bioprospecting.	PSO 2, PSO 5, PSO 6, PSO 8
	CO 4. Categorise fungal diseases and its therapy.	PSO 1, PSO 2, PSO 4, PSO 8

<b>Content:</b>		<b>No of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
<b>Module 1:</b>	Fungal diversity and distribution.		CO1	K1, K2
<b>Module 1.1:</b>	Origin and phylogeny; classification	<b>5</b>	CO1	K1, K2, K4
<b>Module 1.2:</b>	Fungi – Terrestrial and Aquatic A. Terrestrial fungi; Aquatic Fungi: Fresh water fungi; Marine fungi: Coastal and Mangrove, Estuarine, Open Ocean, Polar regions. B. Fungal diversity in Hypersaline waters – Thalassohaline and Athallasohaline: Solar salterns, Salt Lake, Dead Sea.	<b>5</b>	CO1	K1, K2, K3
<b>Module 1.3:</b>	Extremophilic Fungi Oligotrophs, Alkaliphiles, Acidophiles, Barophiles, Psychrophiles, Thermophiles, Halophiles, Osmophiles, Xerophiles. Fungal adaptation to extreme environments.	<b>5</b>	CO1	K2, K3, K4
<b>Module 2:</b>	Physiology and Genetics			
<b>Module 2.1:</b>	Physiology of fungi A. Growth and development B. Fungal hormones- attractants, morphogenesis and differentiation. C. Microbial interactions. D. Secondary metabolites: antimicrobials, mycotoxin, pigments.	<b>5</b>	CO2, CO3	K2, K3, K4
<b>Module 2.2:</b>	Fungal genetics <i>Neurospora</i> and <i>Saccharomyces</i> : Life-cycle; Tetrad analysis, gene conversion; Deuteromycotina: parasexuality, cytoplasmic inheritance; Electrophoretic karyotyping.	<b>5</b>	CO2	K2, K3, K4, K5
<b>Module 2.3:</b>	Identification of fungi A. Colonial and morphological characteristics, standard keys for identification of fungi.	<b>5</b>	CO3	K2, K3, K4

	B. Molecular finger printing.			
<b>Module 3:</b>	Pathogenesis - Antifungal Therapy	<b>8</b>	CO4	
<b>Module 3.1:</b>	Pathogenesis	<b>5</b>	CO4	K1, K2, K4
	A. Mycoses - Systemic, sub-cutaneous, cutaneous and superficial, Opportunistic B. Plant Pathogens			
<b>Module 3.2:</b>	Antifungal Therapy Drugs acting on cell membrane, protein synthesis inhibitors; fungicides.	<b>3</b>	CO4	K2, K3, K4
<b>Module 4:</b>	Applications A. Industrially important enzymes. B. Bioprospecting of secondary metabolites: Antimicrobials, antitumour agents, nutraceuticals, pigments,.. C. Biodegradation and bioremediation. D. Biocontrol E. Edible Mushrooms	<b>7</b>	CO3	K2, K3, K5, K6
<b>Pedagogy:</b>	Lectures/tutorials/assignments			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>1. Deacon, J. W., Introduction to Modern Mycology, Volume 7 of Basic Microbiology, Blackwell Scientific Publications. (2022).</li> <li>2. Chander, J., Textbook of Medical Mycology, Jaypee Brothers Medical Publishers (P) Ltd. Fourth Edition (2018).</li> <li>3. Kendrick, B., The Fifth Kingdom, Focus Publishers. (2017).</li> <li>4. Gilman, J. C. and Joseph, C., A Manual of Soil Fungi, Daya Books. (2015).</li> <li>5. Mehrotra, R. S. and Aneja, K. R., An Introduction to Mycology, Wiley Eastern Limited. (2015).</li> <li>6. Strickberger, M. W., Genetics, The MacMillan Company, New York. (2014).</li> <li>7. Domsch, K. H., Gams, W. and Anderson, T-H., Compendium of Soil Fungi, IHW-Verlag. (2008).</li> <li>8. Alexopoulos, C.J., Mims, C.W. and Blackwell, M., Introductory Mycology, John Wiley &amp; Sons (Asia) Pvt. Ltd. (2007).</li> </ol>			

	<p>9. Onions, A. H. S., Allsop, D. and Eggins, M. O. W., Smith's Introduction to Industrial Mycology, Edward Arnold, London. (2007).</p> <p>10. Cooke, R. C. and Whipps, J. M., Ecophysiology of Fungi, Blackwell Scientific Publications, Oxford. (1993).</p>
<b>References/ Readings:</b>	<p>1. Corbu, V. M., Gheorghe-Barbu, I., Dumbravă, A. Ş., Vrâncianu, C. O., &amp; Şesan, T. E. (2023). Current Insights in Fungal Importance-A Comprehensive Review. <i>Microorganisms</i>, 11(6), 1384.</p> <p>2. Naranjo-Ortiz, M.A. and Gabaldon, T., (2019). Fungal evolution: diversity, taxonomy and phylogeny of the Fungi. <i>Biological Reviews</i>, 94(6):2101–2137.</p>
<b>Web Resources:</b>	<p>1. <a href="https://mycoasia.org/resources/">https://mycoasia.org/resources/</a></p> <p>2. <a href="https://www.mycobank.org/">https://www.mycobank.org/</a></p> <p>3. <a href="https://www.adelaide.edu.au/mycology/">https://www.adelaide.edu.au/mycology/</a></p>



<b>Title of the Course</b>	Mycology [P]	
<b>Course Code</b>	MIC-5208	
<b>Number of Credits</b>	01	
<b>Theory/Practical</b>	Practical	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-2026	
<b>New Course</b>	No	
<b>Bridge Course/ Value added Course</b>	No	
<b>Course for advanced learners</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	To familiarize with techniques related to fungal isolation, identification and application.	
<b>Course Outcomes:</b>	(Mention minimum Four and maximum of Six outcomes) Shall include Cognitive levels as per Bloom's Taxonomy.	<b>Mapped to PSO</b>
	CO 1. Identify the fungal isolates	PSO1, PSO2, PSO3
	CO 2. Isolate DNA from fungi	PSO3, PSO4, PSO5, PSO6
	CO 3. Demonstrate the fungal isolates for bioremedial potentials	PSO4, PSO5, PSO6, PSO7, PSO8
	CO 4. Establish fungal cultures for food security	PSO5, PSO6, PSO8

Content:		No of hours	Mapped to CO	Cognitive Level
<b>Module 1:</b>	1. Study and Identification of fungi: Study of standard cultures and identification - Observation of colonial and morphological characteristics, Reference to identification keys	30	CO1	K2, K3
	2. Fungal Genetics: Isolation of fungal DNA		CO1, CO2	K3, K4
	3. Application of fungi for bioremediation: Fungal degradation of azo Dye		CO1, CO3	K3, K4, K5
	4. Degradation of plant polymer by fungal enzyme (crude)		CO3, CO4	K3, K4, K5
	5. Mushroom cultivation		CO4	K6
<b>Pedagogy:</b>	Hands-on experiments in the laboratory, video, online data			
<b>Texts:</b>	<ol style="list-style-type: none"> <li>Alexopoulos, C.J., Mims, C.W. and Blackwell, M., (2007) Introductory Mycology, Fourth Edition, John Wiley &amp; Sons (Asia) Pvt. Ltd</li> <li>Cooke, R. C. and Whipps, J. M., (1993) Ecophysiology of fungi, Blackwell Scientific Publications, Oxford, Boston.</li> <li>Davis, B. D., Dulbecco, R., Eisen, H. N. and Ginsberg, H. S., (1980) Microbiology, Third Edition, Harper and Row, New York.</li> <li>Deacon, J. W., (1984) Introduction to Modern Mycology, Volume 7 of Basic Microbiology, Blackwell Scientific Publications, Oxford, Boston.</li> <li>Domsch, K. H., Gams, W. and Anderson, T-H., (2008) Compendium of Soil Fungi, Second Edition, IHW-Verlag, Eching.</li> <li>Gilman, J. C. and Joseph, C., (2008) A Manual of Soil Fungi, Second Edition, Biotech Books, Delhi.</li> <li>Kendrick, B., (2017) The Fifth Kingdom, Fourth Edition, Focus Publishers/R Pullins &amp; Co., USA.</li> <li>Mehrotra, R. S. and Aneja, K. R., (2015) An Introduction to Mycology, Second Edition, New Age International Private Limited, New Delhi.</li> <li>Onions, A. H. S., Allsop, D. and Eggins, M. O. W., (2007) Smith's</li> <li>Introduction to Industrial Mycology, Edward Arnold, London.</li> <li>Strickberger, M. W., (2014) Genetic, The MacMillan Company, New York.</li> </ol>			
<b>References/ Readings:</b>	<a href="#">Garcia-Rubio R., de Oliveira H.C., Rivera J., and Trevijano-Contador N., (2020) The Fungal Cell Wall: <i>Candida</i>, <i>Cryptococcus</i>, and <i>Aspergillus</i> Species Front. Microbiol,10:2993. doi: 10.3389/fmicb.2019.02993</a>			
<b>Web Resources:</b>	<a href="https://www.scribd.com/document/142754592/fungal-genetics-pdf">https://www.scribd.com/document/142754592/fungal-genetics-pdf</a>			

<b>Title of the Course</b>	Internship	
<b>Course Code</b>	MIC-5209	
<b>Number of Credits</b>	4	
<b>Theory/Practical</b>	Practical	
<b>Level</b>	400	
<b>Effective from AY</b>	2025-2026	
<b>New Course:</b>	Yes	
<b>Bridge Course/</b>	No	
<b>Course for advanced learners:</b>	No	
<b>Pre-requisites for the Course:</b>	Nil	
<b>Course Objectives:</b>	<ol style="list-style-type: none"> <li>1. To apply knowledge of microbiology, clinical testing/quality assurance methodologies relevant to the microbiology, and management practices in real-world settings within clinical laboratories/microbiology production facilities.</li> <li>2. To analyze and evaluate current practices in microbial process and production, diagnostics, quality testing procedures, and hygiene protocols observed during their internship, identifying areas of strength and potential improvement based on knowledge and industry/clinical laboratory best practices.</li> <li>3. To develop essential professional skills such as effective communication, teamwork, problem-solving, and time management through active participation in internship tasks and interactions with industry/hospital/laboratories professionals.</li> <li>4. To critically reflect on their experiential learning by connecting their practical observations and tasks within the hospital/laboratory/industry to relevant academic concepts and theories, and to articulate their personal and professional growth gained through the internship.</li> </ol>	
<b>Course Outcomes:</b>	<b>On the completion of the course, the student will be able to:</b>	<b>Mapped to PSO</b>

	CO 1. Demonstrate an understanding of the key stages in production within a specific industry.		PSO 1	
	CO 2. Apply basic principles of clinical and quality testing relevant to the Indian context.		PSO 1, PSO 2, PSO 4	
	CO 3. Identify and analyze hygiene and sanitation practices in production.		PSO 1, PSO 2, PSO 4	
	CO 4. Document and critically reflect on their internship experiences and learning outcomes.		PSO 8	
	CO 5. Communicate effectively about their observations and contributions during the internship.		PSO 1, PSO 6, PSO 8	
	CO 6. Understand the professional expectations and ethical considerations within industry.			
<b>Content:</b>	<b>Internship Duration (60 hours)</b>	<b>No. of hours</b>	<b>Mapped to CO</b>	<b>Cognitive Level</b>
	<b>Components of the Internship</b>			
	1.1 Mandatory On-Site Work: A minimum of 120 hours spent at the host organization(s) engaging in the activities.	<b>120</b>	CO 1, CO 2, CO 3, CO 4, CO 5	K4, K5, K6
	1.2 Reflective Journaling: Regular and detailed entries in a reflective journal documenting observations, tasks performed, challenges faced, and learning insights.		CO 4, CO 5	K4, K5, K6
	1.3 Internship Report: A comprehensive written report detailing the internship experience, including a description of the host organization(s), specific tasks undertaken, key learnings related to microbial production, quality testing, and hygiene management, and a critical reflection on the overall experience and its connection to their academic studies.		CO 3, CO 4	K4, K5, K6
1.4 Supervisor Evaluation: Formal feedback provided by the internship supervisor(s) on the student's performance, professionalism, and	CO 5		-	

	engagement.			
	1.5 Presentation: A brief presentation to faculty summarizing the internship experience and key takeaways.		CO 4, CO 5	K4, K5, K6
<b>Pedagogy:</b>	Hands-on-training, Experiential learning, Reflective journaling, Seminars			

