GSFC UNIVERSITY
EDUCATION RE-ENVISIONED
An ISO 9001:2015 Certified

COURSE CURRICULUM

M.Sc. Microbiology

Batch:2025-2027
Academic Year: 2025-26
Updated on: May, 2025

GSFC University
School of Sciene, Vigyan Bhavan, P. O. Fertilizernagar, Vadodara - 391750, Gujarat, India

M.Sc. Microbiology

VISION

- GSFCU strives to be the best compact boutique institution with a futuristic approach, encouraging student centric culture and sharpened focus on developing industry ready & employable students with all-round development.

MISSION

- Establish an institution, which promotes creativity and innovation.
- Develop unique quality standards for academic excellence and pedagogical innovations.
- Remain agile through learning ecosystem with flexible processes & systems.
- Holistic growth for industry readiness.

No.	Programme Outcomes (POs)	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
PO1	To impart knowledge regarding basic concepts of applied biological sciences.	Basic Knowledge	Explain, Describe, Discuss, Recall, Locate
PO2	To explain the relationships between biological sciences, chemical sciences, physical sciences and mathematical sciences.	Interdisciplinary approach	Apply, Practice, Interpret, Select, Correlate
PO3	To perform procedures as per laboratory standards in the areas of Biological Sciences and to think analytically.	Practical learning	Compare, Classify, Select, Investigate
PO4	To communicate effectively in terms of reading, writing, speaking and delivering the view to others.	Effective Communication and social Interaction	Explain, Describe, outline, Predict, Summarize
PO5	To culminate and understand the moral values for any of the subjects with respect to good practices and humanity.	Ethics	Judge, Assess, Estimate, Predict, Argue
PO6	To explain the importance of ecological balance along with conservation of natural resources for human well being.	Environment and Sustainability	Construct, Develop, Produce

No.	Programme Specific Outcomes (PSOs)	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
PSO1	Understanding of biotechnology related research and industrial applications.	Remembering and Understanding	Explain, Describe, Discuss, Recall, Locate
PSO2	Expertise in interpreting complex data related to biotechnology problems and challenges.	Application and Analysing	Apply, Practice, Interpret, Select, Correlate
PSO3	Expertise in knowledge needed to solve current and emerging technologies.	Analysing	Compare, Classify, Select, Investigate
PSO4	Understanding related to questions they need to ask and in – depth research they need to conduct.	Understanding	Explain, Describe, outline, Predict, Summarize
PSO5	Expertise in communicating issues related to industrial biotechnology to a wide audience.	Evaluating	Judge, Assess, Estimate, Predict, Argue
PSO6	Expertise in solving complex social and ethical problems confronting the industry and the government.	Creating	Construct, Develop, Produce

Mapping of POs & PSOs:

	PO1	PO2	PO3	PO4	PO5	PO6
PSO1	2	2	3	3	3	2
PSO2	3	2	2	2	3	3
PSO3	3	3	3	2	2	1
PSO4	3	3	2	2	2	2
PSO5	2	3	2	3	2	2
PSO6	2	2	2	2	3	2
Avg.	2.5	2.5	2.3	2.3	2.5	2

1: Slight (Low); 2: Moderate (Medium); 3: Substantial (High); 0 None

No.	Programme Educational Outcomes (PEOs)	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
PEO1	Graduates will excel in careers related to clinical diagnostics, food and dairy microbiology, environmental microbiology, or research and development organizations.	Basic Knowledge	Explain, Describe, Discuss, Recall, Locate
PEO2	Graduates will undertake doctoral studies and/or participate in lifelong learning to remain current with advancements in microbiology and allied fields.	Practical learning	Apply, Practice, Interpret, Select, Correlate
PEO3	Graduates will demonstrate strong analytical, problem-solving, and communication skills while working in multidisciplinary teams and professional settings.	Interdisciplinary learning	Compare, Classify, Select, Investigate
PEO4	Graduates will contribute to sustainable development and innovation by addressing societal, environmental, and industrial challenges through biotechnology.	Environment and Sustainability	Explain, Describe, outline, Predict, Summarize
PEO5	To develop and understand the ethical values for any of the subjects with respect to good practices and humanity.	Ethics	Judge, Assess, Estimate, Predict, Argue

Mapping of POs & PEOs:

	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	3	3	3	3	3	2
PEO2	3	2	2	2	3	3
PEO3	3	3	3	2	2	1
PEO4	3	3	3	2	2	2
PEO5	2	3	2	3	2	2
Avg.	2.5	2.5	2.3	2.3	2.5	2

Definition of Credit:

1 Hour Lecture (L) per week	1 credit
1 Hour Tutorial (T) per week	1 credit

2 Hours Practical (P) per week	1 credit
1 Hour Practical (P) per week	0.5 credit
3 Hours Experiential learning	1 credit

Course code Definitions:

Lecture	L
Tutorial	T
Practical	P
Professional core courses /Major (Core)	PCC
Professional Elective courses /Minor Stream	PEC
Open Elective courses	OEC
Non-credit courses	NC
Project (Experiential learning)	PROJ
Experiential learning ex. Internship, Industrial Visit, Field visit, etc,	EL
Multidisciplinary courses	MDC
Ability Enhancement Course	AEC
Skill Enhancement Course	SCE
Value Added Courses	VAC

Structure of Postgraduate Programme:

Sr. No.	Category	Credit Breakup
1	Professional core courses -**Major (Core)**	45
2	Professional Elective courses relevant to chosen specialization/branch - **Minor Stream**	19
3	Project work, seminar and internship in industry or elsewhere	26
4	Multidisciplinary courses	15
	Total	**105**

1. Professional Major Courses (Core)

i. Number of Professional Core Courses (Major): 9
ii. Credits: 45

Sr. No.	Course Code	Course Name	Semester	Teaching Scheme (Hours/week)				Teaching Credit			
				L	P	T	Total	L	P	T	Total
1	MSMI131	Advanced Biomolecules & Biochemistry	I	3	2	0	5	3	2	0	5
2	MSMI132	Basics of Bioinformatics	I	2	2	1	5	2	2	1	5
3	MSMI133	General Microbiology	I	3	2	0	5	3	2	0	5
4	MSMI134	Molecular Diagnostics	I	3	2	0	5	3	2	0	5
5	MSMI231	Microbial physiology and metabolism	II	3	2	0	5	3	2	0	5
6	MSMI233	Bioprocess Engg. and Technology	II	3	2	0	5	3	2	0	5
7	MSMI234	Medical Microbiology	II	3	2	0	5	3	2	0	5
8	MSMI323	Pharmaceutical microbiology	III	3	2	0	5	3	2	0	5
9	MSMI324	Environmental microbiology	III	3	2	0	5	3	2	0	5
		Total		**26**	**18**	**1**	**45**	**26**	**18**	**1**	**45**

2. Multidisciplinary Courses (MDC)

i. Number of Multidisciplinary Courses:04
ii. Credits: 15

Sr. No.	Course Code	Course Name	Semester	Teaching Scheme (Hours/week)				Teaching Credit			
				L	P	T	Total	L	P	T	Total
1	MSMI238	Nano Science	II	3	2	0	5	3	2	0	5
2	MSMI322	Emerging Technology	III	3	2	0	5	3	2	0	5
3	MSMI318	Ecology & Evolution	III	3	0	0	3	3	0	0	3
4.	NOC01	NPTEL	III	0	2	0	2	0	2	0	2
		Total		**9**	**6**	**0**	**15**	**9**	**6**	**0**	**15**

3. Skill Enhancement Courses (Internships & Dissertation)

i. Number of Skill Enhancement Courses:04
ii. Credits: 26

Sr. No.	Course Code	Course Name	Semester	Teaching Scheme (Hours/week)				Teaching Credit			
				L	P	T	Total	L	P	T	Total
1	MSMI138	Internship	I	0	2	0	2	0	2	0	2
2	MSMI237	Internship	II	0	2	0	2	0	2	0	2

3	MSMI328	Internship	III	0	2	0	2	0	2	0	2
4	MSMI401	Dissertation & Viva	IV	0	20	0	20	0	20	0	20
		Total		**0**	**26**	**0**	**26**	**0**	**26**	**0**	**26**

4. Elective courses

i. Number of Skill Enhancement Courses: 08
ii. Credits: 19

Sr. No.	Course Code	Course Name	Semester	Teaching Scheme (Hours/week)				Teaching Credit			
				L	P	T	Total	L	P	T	Total
1	MSMI135	Biostatistics	I	2	0	0	2	2	0	0	2
2	MSMI137	Genetics	I	2	0	0	2	2	0	0	2
3	MSMI136	Biopython	I	2	0	0	2	2	0	0	2
4	MSMI232	Research Methodology & IPR	II	2	0	0	2	2	0	0	2
5	MSMI236	Advance biopython	II	2	0	0	2	2	0	0	2
6	MSMI325	Agriculture Microbiology	III	3	0	0	3	3	0	0	3
7	MSMI326	Food technology	III	3	0	0	3	3	0	0	3
8	MSMI327	Ecology and evolution	III	3	0	0	3	3	0	0	3
		Total		**19**	**0**	**0**	**19**	**19**	**0**	**0**	**19**

About the Programme:

Science is the basic foundation of any technological and engineering creation. In view of the changing scenario at the national and international level in the field of Science and Technology, there is a great demand for basic sciences with considerable knowledge of its applications. GSFC University is committed to high academic standards.

The M.Sc. Microbiology Program is degree which is designed for four Semesters in such a way that a good basic foundation of subjects is laid and applications along with recent developments are covered. Students will also get theoretical and practical knowledge by undergoing industrial internship after every semester.

The more focused specialization course of Microbiology is designed to full fill recent demands of industrial career.

Teaching and Examination Scheme

Semester I

Sr. No.	Course Code	Course Name	Course Type	L	T	P	T	P	MSE	CEC	ESE	LW	LE/VIVA	Total Marks
1	MSMI131	Advanced Biomolecules	Compulsory	3	0	2	05		20	40	40	50		150

		& Biochemistry										
2	MSMI1322	Basics of Bioinformatics	Compulsory	2	1	2	05	20	40	40	50	150
3	MSMI133	General Microbiology	Compulsory	3	0	2	05	20	40	40	50	150
4	MSMI134	Molecular Diagnostics	Compulsory	3	0	2	05	20	40	40	50	150
5	MSMI135	Biostatistics	Elective	2	0	0	02	20	40	40	00	100
6	MSMI136	Biopython	Elective	2	0	0		20	40	40		
7	MSMI137	Genetics	Elective	2	0	0		20	40	40		
8	MSMI138	Internship	Compulsory Skill Enhancement	0	0	2	02	0	0	0	50	50
	Total						**24**					**750**

Semester II

Sr. No.	**Course Code**	**Course Name**	**Course Type**	**L**	**T**	**P**	**T**	**P**	**MSE**	**CEC**	**ESE**	**LW**	**LE/VIVA**	**Total Marks**
1	MSMI231	Microbial physiology and metabolism	Compulsory	3	0	2	05		20	20	40	50		50
2	MSMI238	Nanoscience	Compulsory	3	0	0	05		20	20	40	50		
3	MSMI233	Bioprocess Engg. and Technology	Compulsory	3	0	2	05		2	20	40	50		50
4	MSMI234	Medical Microbiology	Compulsory	3	0	2	05		2	20	40	50		50
5	MSMI232	Research methodology and IPR	MDC/Elective	3	0	2	02		20	20	40	00		50
6	MSMI236	Advanced Biopython	Elective	2	0	0			20	20	40			
7	MSMI237	Internship	Compulsory Skill Based	0	0	2	02		2	0	0			50
	Total						**24**							**750**

Semester III

Sr. No.	**Course Code**	**Course Name**	**Course Type**	**L**	**T**	**P**	**T**	**P**	**MSE**	**CEC**	**ESE**	**LW**	**LE/VIVA**	**Total Marks**
1	MSMI321	Project Proposal Prep.	Core	3	0	2	05		20	20	40	50		150
2	MSMI322	Emerging Technology	MDC	3	0	0	05		20	20	40	50		150
3	MSMI323	Pharmaceutical microbiology	Core	3	0	2	05		2	20	40	50		150
4	MSMI324	Environmental microbiology	Core	3	0	2	05		2	20	40	50		150
5	MSMI325	Agriculture Microbiology	Elective	3	0	0	03		20	20	40	00		100

6	MSMI326	Food Technology	Elective	3	0	0		20	20	40		
7	MSMI327	Ecology & Evolution	MDC	3	0	0		20	20	40		
8	NOC01	NPTEL Online Courses	Elective	0	0	0	02	0	0	0	00	100
9	MSMI328	Internship+Dissertation clubed	Skill Based	0	0	2	02	0	0	0	00	50
	Total						**27**					**850**

Semester IV

Sr. No.	Course Code	Course Name	Course Type	L	T	P	T	P	MSE	CEC	ESE	LW	LE/VIVA	Total Marks
1	MSMI411	Dissertation & Viva	Project Work	0	0	20	20		00	00	00	100		100
	Total						**20**							**100**

COURSE CODE MSIM131	COURSE NAME ADVANCED BIOMOLECULES AND BIOCHEMISTRY	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	4	0	45+60	3	2	0	5

Course Pre-requisites	Students should have basic knowledge about advanced biomolecules and biochemistry
Course Category	Core Professional.
Course focus	Scientific Temperament & Employability
Rationale	Advanced biomolecules and biochemistry are vital for students as they provide a comprehensive understanding of the molecular basis of life processes, laying the foundation for research and innovation in biotechnology, medicine, and drug discovery, thereby preparing students for careers in academia, industry, and healthcare.
Course Revision/ Approval Date:	06/03/24
Course Objectives (As per Blooms' Taxonomy)	1. **Remember** To introduce the field of advanced biomolecules and biochemistry. 2. **Apply** To understand advanced biomolecules and biochemistry. 3. **Analyses** Understanding of advanced biomolecules and biochemistry 4. **Create** Understanding of strategies to study advanced biomolecules and biochemistry 5. **Understand** advanced biomolecules and biochemistry

Course Content (Theory)	Weightage	Contact hours
Unit 1: Carbohydrate and its metabolism: Structure, classification, function, clinical significance and metabolism.	**20%**	**9**
Unit 2: Protein and amino acid and it's metabolism: Structure, classification, function, clinical significance and metabolism.	**20%**	**9**
Unit 3: Lipids and it's metabolism: Structure, classification, function, clinical significance and metabolism.	**20%**	**9**
Unit 4: Nucleic acid and it's metabolism: Structure, classification, function, clinical significance and metabolism.	**20%**	**9**
Unit 5: Cell membrane: It's integrity, complexity and molecular structure.	**20%**	**9**
Practical: 1.Preparing various stock solutions and working solutions that will be needed for the course. 2 To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law. 3 To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbeck Equation. 4 Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography. 5 Experimental verification that absorption at OD260 is more for denatured DNA as compared to native double stranded DNA. 6 Reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size. 7 Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments) 8 Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy). (Online: Video Tutorials) 9 Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry (Online: Video Tutorials)		

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to: **CO1** They will be able to recall and describe key biochemical pathways and processes involved in metabolism, signaling, and regulation within living organisms.	Remember	Explain, Describe, Discuss, Recall,
CO2 They will demonstrate the ability to summarize and compare different biochemical processes and their significance in cellular function and organismal physiology.	Apply	Interpret, Select,
CO3 Students will critically evaluate scientific literature and research findings related to advanced biomolecules and biochemistry, identifying strengths, weaknesses, and gaps in existing knowledge.	Analyses and Evaluation	Compare, Classify, Select,
CO4 Utilizing their knowledge of biomolecules and biochemical principles, students will analyze experimental data and design experiments to investigate biological questions or solve practical problems.	Create	Construct, Develop,
CO5 They will demonstrate creativity and innovation in problem-solving, synthesizing information to generate new insights or applications in biotechnology, medicine, or other relevant fields.	Understand	Explain, Describe, outline, Predict, Summarise

Learning Resources	
1.	Textbook & Reference Books 1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006).Biochemistry. VI Edition. 2. W.H Freeman andCo. 2. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists. 3. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, US 4. A.L. Lehninger: Biochemistry.
2.	Journals & Periodicals 1. JBC 2. Current Science
3	Other Electronic resources: NPTEL

<table>
<tr><th>Evaluation Scheme</th><th>Total Marks</th></tr>
<tr><td>Theory: Mid semester Marks</td><td>20 marks</td></tr>
<tr><td>Theory: End Semester Marks</td><td>40 marks</td></tr>
<tr><td>Theory: Continuous Evaluation Component Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>MCQs</td><td>10 marks</td></tr>
<tr><td>Skill enhancement activities / case study</td><td>15 marks</td></tr>
<tr><td>Presentation/ miscellaneous activities</td><td>10 marks</td></tr>
<tr><td>Total</td><td>40 Marks</td></tr>
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<tr><td>Practical Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>Practical Exam</td><td>30 marks</td></tr>
<tr><td>Viva</td><td>10 marks</td></tr>
<tr><td>Journal</td><td>5 marks</td></tr>
<tr><td>Total</td><td>50 Marks</td></tr>
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Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	1	-	2	1	1	-
CO2	1	3	2	2	-	-
CO3	1	-	-	1	2	1
CO4	2	3	2	-	2	2
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	2	-	2	2	1
CO2	-	1	1	2	-	-
CO3	2	-	-	1	2	1
CO4	2	1	2	3	2	2
CO5	-	1	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURS CODE MSMI132	COURSE NAME BASICS OF BIOINFORMATICS	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
2	4	1	30+60+15	2	2	1	5

Course Prerequisites	Basic Knowledge of computers
Course Category	Core
Course focus	Scientific Temperament & Employability
Rationale	Know how to develop your skills in Python Retrieve and analyze the biological data
Course Revision/ Approval Date:	09/05/2025
Course Objectives (As per Blooms' Taxonomy)	• **To Remember** Recall fundamental concepts of molecular biology—including DNA, RNA, and protein structures—and understand bioinformatics databases and tools such as NCBI, BLAST, and GenBank. • **To Understand** and Explain the role of bioinformatics in analyzing biological data and its importance in modern research. • **To Analyze Analyze** Interpret biological datasets to identify patterns and relationships.Evaluate the results of bioinformatics tools to draw meaningful conclusions**.** • **To Apply** Utilize bioinformatics software to perform sequence analysis and data visualization. • **To Create** Develop simple bioinformatics pipelines to address specific biological questions

Course Content Theory	**Weigh tage**	**Contact hours**
Unit 1: Introduction to Bioinformatics . Explore bioinformatics fundamentals, applications, and key biological databases, including protein, nucleic acid, and structural databases	**20%**	**6**
Unit 2: Pair wise alignment: Introduction, Dot Plot, Dynamic Programming, K- tuple, Fasta, Blast and introduction to scoring matrices	**20%**	**6**
Unit 3: Overview of Multiple Sequence Alignment (MSA), covering its introduction, key algorithms—including dynamic programming, progressive, and iterative methods—and commonly used tools.	**20%**	**6**
Unit 4: Phylogenic Analysis: Concepts of neutral evolution, molecular divergence and molecular clocks; Phylogenetic representations, Definition and description, various types of trees; Steps in constructing a tree Phylogenetic analysis algorithms: Maximum Parsimony, UPGMA, Transformed Distance, Neighbors-Relation and Neighbor-Joining	**20%**	**6**
Unit 5: Data ethics and Database: Data ethics, Introduction to Databases, DBMS Definition, Characteristics of DBMS, Application and advantages of DBMS	**20%**	**6**

Practicals:

1. Retrieving sequences from public Nucleotide databases (e.g., NCBI GenBank, EMBL, DDJB).
2. Retrieving sequences from public Protein databases (UniProt)
3. Retrieving sequences from public Protein Structural databases (PDB)
4. Performing sequence similarity searches using tools like BLAST (Basic Local Alignment Search Tool).
5. Pairwise sequence alignment (e.g., global alignment, local alignment) using tools such as EMBOSS Needle or BLAST.
6. Multiple sequence alignment (e.g., using ClustalW, MUSCLE) to align multiple sequences for comparative analysis.
7. Identifying open reading frames (ORFs) in nucleotide sequences.
8. Predicting protein structure and function from amino acid sequences using tools like InterProScan or Pfam.
9. Constructing phylogenetic trees using various methods (e.g., Neighbor-Joining, Maximum Likelihood).

Tutorial

SNo	Name	Contact hrs
1	Unit 1: Introduction to Bioinformatics	3hrs
2	Unit 2: Pair wise alignment	3hrs
3	Unit 3: Overview of Multiple Sequence Alignment (MSA)	3hrs
4	Unit 4: Phylogenic Analysis:	3hrs
5	Unit 5: Data ethics and Database	3hrs

Learning Resources	
1.	**Textbook & Reference Book** 1. Lesk,A.M.(2002).IntroductiontoBioinformatics.Oxford:OxfordUniversityPress. 2. Mount, D. W.(2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring 3. Harbor, NY: Cold Spring Harbor Laboratory Press. 4. Baxevanis, A. D.,& Ouellette, B. F.(2001). Bioinformatics: a Practical Guide to the 5. Analysis of Genes and Proteins. New York:Wiley-Interscience. 6. Pevsner,J.(2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell
2.	**Journals & Periodicals** 1. Journal of Bioinformatics and Computational Biology 2. Bioinformatics 3. Bioinformatics and Biology Insights 4. BMC Bioinformatics 5. Briefings in Bioinformatics
3	**Other Electronic resources**: 1) MH Education 2) NPTEL 3) Coursera

Evaluation Scheme	**Total Marks 100**
Mid semester Marks	20

End Semester Marks	40	
Continuous Evaluation Marks	Attendance	5 marks
	Quiz	10 marks
	Skill enhancement activities / case study	10 marks
	Presentation/ miscellaneous activities	15 marks

Course Outcomes	1.Develop an understanding of basic theory of biological databases.
	2. Appreciate their relevance for investigating specific contemporary biological questions through the use of bioinformatics tools
	3. Critically analyse and interpret results of bioinformatic analysis
	4. Develop the abilities for conducting in silico experiments.
	5. Demonstrate mastery of the core concepts of Bioinformatics
Additional Information to enhance learning	Expert talk required on specific topics.

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	1	-	2	1	1	-
CO2	1	3	2	2	-	-
CO3	1	-	-	1	2	1
CO4	2	3	2	-	2	2
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	2	-	2	2	1
CO2	-	1	1	2	-	-
CO3	2	-	-	1	2	1
CO4	2	1	2	3	2	2
CO5	-	1	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSIM133			COURSE NAME GENERAL MICROBIOLOGY			SEMESTER I	
Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	4	0	45+60	3	2	0	5

Course Pre-requisites	Students should have basic knowledge about Microbiology.
Course Category	Specialization
Course focus	Employability
Rationale	To have an overview of microbial response and it's components. The subject also explains the structure, function and regulation of Bacterial, Virus, Fungus and their effect on Human, environment.
Course Revision/ Approval Date:	06/03/24
Course Objectives **(As per Blooms' Taxonomy)**	1. **Remember** To introduce the field of microbiology with special emphasis on microbial diversity. 2. **Apply** To study microbial morphology, physiology and nutrition. 3. **Analyses** To know the methods of culturing microorganisms 4. **Create** To get insights in the methods involved in controlling growth of microbes. 5. **Understand** Host- microbe interactions.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Introduction to Microbiology: History and scope of microbiology,Microbial diversity and classification, Microscopic techniques for studying microorganisms, Microbial cell structure and function	**20%**	**9+4**
Unit 2: Microbial Nutrition, Growth and Metabolism: Microbial nutrition and culture media, Bacterial growth kinetics, Factors affecting microbial growth, Metabolic diversity among microorganisms	**20%**	**9+4**
Unit 3: Environmental microbiology: microbial ecology, bioremediation, and wastewater treatment, Medical microbiology: diagnosis, treatment, and prevention of infectious diseases	**20%**	**9+4**
Unit 4: Microbial Pathogenesis: Host-microbe interactions, Mechanisms of bacterial and viral pathogenesis, Immune response to microbial infections, Epidemiology and control of infectious diseases	**20%**	**9+4**
Unit 5: Applied Microbiology: Industrial microbiology: fermentation and biotechnology, Agricultural microbiology: plant-microbe interactions, biofertilizers, and biopesticides	**20%**	**9+4**
Practicals: 1. Gram staining technique to differentiate between Gram-positive and Gram-negative bacteria. 2. Simple staining techniques (e.g., using methylene blue, crystal violet) to observe bacterial morphology. 3. Inoculation techniques (streak plate, spread plate, pour plate) to isolate bacterial colonies. 4. Pure culture techniques and maintenance of bacterial cultures. 5. Biochemical tests.		

Instructional Method and Pedagogy:

Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1 To introduce the field of microbiology with special emphasis on microbial diversity.	Remember	Explain, Describe, Discuss, Recall, Locate
CO2 To study microbial morphology, physiology and nutrition.	Apply	Apply, Practice, Interpret, Select, Correlate
CO3 To know the methods of culturing microorganisms	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 To get insights in the methods involved in controlling growth of microbes	Create	Construct, Develop, Produce
CO5 Host- microbe interactions	Understand	Explain, Describe, outline, Predict, Summarise

Learning Resources	
1.	Reference books: 1. Textbook 1. D.K Maheshwari (1999) A textbook of Microbiology 2. R.Vasanthakumari (2007) Textbook of Microbiology. 3. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). Microbiology (5th ed.). New York: McGraw-Hill.. 4. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's Microbiology. New York: McGraw-Hill.. 5. Matthai, W., Berg, C. Y., & Black, J. G. (2005). Microbiology, Principles and Explorations. Boston, MA: John Wiley & Sons. 6
2.	Journals & Periodicals 1. Journal of Microbiology 2. Current Science Journal, Indian journal of Biotechnology 3. Nature Review microbiology 4. Macromolecules
5	Other Electronic resources: 1) MH Education 2) NPTEL

Evaluation Scheme	Total Marks

<table>
<tr><td>Theory: Mid semester Marks</td><td>20 marks</td></tr>
<tr><td>Theory: End Semester Marks</td><td>40 marks</td></tr>
<tr><td>Theory: Continuous Evaluation Component Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>MCQs</td><td>10 marks</td></tr>
<tr><td>Skill enhancement activities / case study</td><td>15 marks</td></tr>
<tr><td>Presentation/ miscellaneous activities</td><td>10 marks</td></tr>
<tr><td>Total</td><td>40 Marks</td></tr>
</table>
</td></tr>
<tr><td>Practical Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>Practical Exam</td><td>30 marks</td></tr>
<tr><td>Viva</td><td>10 marks</td></tr>
<tr><td>Journal</td><td>5 marks</td></tr>
<tr><td>Total</td><td>50 Marks</td></tr>
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</td></tr>
</table>

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO 1	1	-	2	1	1	-
CO 2	1	3	2	2	-	-
CO 3	1	-	-	1	2	1
CO 4	2	3	2	-	2	2
CO 5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO 1	3	2	-	2	2	1
CO 2	-	1	1	2	-	-
CO 3	2	-	-	1	2	1
CO 4	2	1	2	3	2	2
CO 5	-	1	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSIM134	COURSE NAME MOLECULAR DIAGNOSTICS	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	4	0	45+60	3	2	0	5

Course Pre-requisites	Students should know have basic knowledge of molecular diagnostics.
Course Category	Specialization
Course focus	Specialization
Rationale	Scientific Temperament & Employability
Course Revision/ Approval Date:	6/03/2024
Course Objectives (As per Blooms' Taxonomy)	1. The objectives of this course are to sensitize students about recent advances in diagnostics and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including preor post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer 2. Adequate knowledge about recent advances and technological developments in the field of diagnostics 3. Selection of an appropriate diagnostic method/tool for a particular disease condition and sample type. 4. Expertise to perform any diagnostic test with an ability to troubleshoot. 5. The objectives of this course are to sensitize students about recent advances in molecular biology.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Introduction to Molecular Diagnostics	**20%**	**10**
Unit 2: Nucleic Acid Amplification Techniques	**20%**	**10**
Unit 3: Regression Analysis: Simple linear regression, Multiple linear regression, Logistic regression, Model diagnostics and interpretation	**20%**	**10**
Unit 4: Survival Analysis: Kaplan-Meier estimator, Cox proportional hazards model, Survival curves and censoring, Applications in clinical trials and epidemiological studies.	**20%**	**10**
Unit 5: Diagnostic Assays for Infectious Diseases and Epidemiological Study Designs: Observational studies vs. experimental studies, Cross-sectional studies, Cohort studies, Meta-analysis	**20%**	**05**
Practicals: • Extraction of DNA and RNA from various sample types (e.g., cells, tissues, blood) using different methods (e.g., phenol-chloroform extraction, silica-based columns). • Setting up and performing PCR reactions to amplify specific DNA sequences. • Assessment of nucleic acid quality and quantity (e.g., spectrophotometry, fluorometry) • Quantitative measurement of DNA or RNA targets. By using RT PCR		

Instructional Method and Pedagogy: Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to: **CO1** Able to understand various facets of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases	Understand, Remember& apply	Explain, Describe, Discuss, Recall, Locate

CO2 Acquire knowledge of various diagnostic tools used in healthcare, industry and research **CO3** Identify the role and importance of molecular diagnostics such as real-time PCR, epidemiological genotyping, microfluidics, bio-imaging and sequencing technologies **CO4** Students will be able to Incorporate both in silico and lab based techniques as part of a combined molecular diagnostics strategy. **CO5** Perform selected laboratory techniques, interpret results and prepare reports	Apply Evaluate Apply Understand, Remember& apply	Apply, Practice, Interpret, Select, Correlate Compare, Classify, Select, Investigate Construct, Develop, Produce Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook 1. Campbell, A. M., & Heyer, L. J. (2006). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings. 2. Brooker, R. J. (2009). Genetics: Analysis & Principles. New York, NY: McGraw- Hill. 3. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington, DC: ASM Press. 4. Coleman, W. B., & Tsongalis, G. J. (2010). Molecular Diagnostics: for the Clinical Laboratorian. Totowa, NJ: Humana Press.
2	Reference book : Molecular Diagnostics, 3rd Edition Editors: George P. Patrinos Wilhelm Ansorge Phillip B. Danielson. Hardcover ISBN: 9780128029718. eBook ISBN: 9780128029886
3	Journal : Journal of Molecular Diagnostics, Nature reviews
5	Periodicals: Current science
6	Other Electronic resources: NPTL and UGC Pathshala lectures

<table>
<tr><th>Evaluation Scheme</th><th>Total Marks</th></tr>
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<tr><td>Total</td><td>50 Marks</td></tr>
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Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	3	3	1	2	0	3
CO2	2	2	3	2	1	2
CO3	3	2	3	2	2	2
CO4	2	3	2	2	1	1
CO5	3	2	2	1	2	0

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	2	0	0	2	0
CO2	3	2	3	1	2	2
CO3	2	3	3	1	2	2
CO4	1	3	2	1	3	3
CO5	2	2	3	2	3	0

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSIM135	COURSE NAME BIOSTATISTICS	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
30	0	0	30	2	0	0	2

Course Pre-requisites	Students should have basic Biostatistics
Course Category	Elective
Course focus	Skill development
Rationale	In this course students will learn descriptive statistics and its basic applications in real life. Students will also learn different types of tests for Hypothesis testing. Sutdents will understand the concepts of correlation and learn the methods of regression. They will also get an exposure to differntial and integral calculus and learn to solve the system of linear equations.
Course Revision/ Approval Date:	06/3/24
Course Objectives **(As per Blooms' Taxonomy)**	To enable the student to: **1 Remember:** Use mean and variance to visualise the data and making decisions. **2 Apply:** Use the degree and direction of association between two variables, and fit a regression model to the given data **3 Understand, Apply:** Identify the type of statistical situation to which different tests can be applied. **4 Understand:** the fundamental concepts of Derivatives and Integration of functions **5 Understand, Apply:** Explain what is meant by statistical inference and concepts of approximation for system of equations

Course Content (Theory)	Weightage	Contact hours
Unit 1: Limits, Complete and Partial Differentials of Function	**20%**	**6**
Unit 2: Majors of Central tendency and Measures of dispersion	**20%**	**6**
Unit 3: Introduction to theory of Probability and Theoitical Distribution	**20%**	**6**
Unit 4: Correlation Analysis and Regression Analysis	**20%**	**6**
Unit 5: Statistical Inference and Tests of Hypothesis, ANNOVA	**20%**	**6**

Instructional Method and Pedagogy: Chalk-board, Presentation, Use ofGeogebra. Group Discussion, Case Study, Quizziz application.

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Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1: **Apply:** Calculate the simple linear regression equation for a set of data and able to solve the system of equations	Apply	Describe, Find
CO2: **Remember, Understand:** Know the practical issues arising in sampling studies	Remember, Understand	Demonstrate & Examine, Find
CO3: **Apply, Analyse:** Appropriately interpret results of analysis of variance tests, would be able to understand the variation in distribution of the data and importance of hypothesis testing using different tests.	Apply, Analyse:	Describe, Demonstrate & Examine, Find
CO4: **Analyse:** Analyse statistical data using MS-Excel.The student would be able to correlate the given data and estimate the value of unknown variable.	Analyse:	Describe, Demonstrate & Examine

Learning Resources	
1.	Reference Books: 1. Probability and Statistics By T K V Iyengar, S chand, 3rd Edition, 2011. 2. Fundamentals of Mathematical Statistics by S C Gupta & V K Kapoor, Sultan Chand & Sons, New Delhi 2009.

2.	Journals & Periodicals:
3.	Other Electronic Resources: Geometry and Algebra: Geogebra.org/Calculator MATLAB : Mathworks.com/ https://www.tutorialspoint.com/matlab/matlab_syntax.htm

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	Attendance: 05 marks MCQs: 10 marks Open Book Assignment: 15 marks Open Book Assignment: 10 marks **Total: 40 Marks**
Practical Marks	Attendance: 05 marks Practical Exam: 20 marks Viva: 10 marks Journal: 10 marks Discipline: 05 marks **Total: 50 Marks**
Project/ Industrial Internship Marks	Quantity of the Project/Industrial in terms of Language, Presentation & format.: 30 marks Practical understanding of the subject on the Project/Industrial.: 30 marks Industry/ University mentor's feedback on the Project/ Industrial.: 30 marks Attendance: 10 marks **Total: 100 Marks**

Mapping of PSOs & COs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	1	2	0	0	0	1	1
CO2	1	2	0	0	0	1	1
CO3	1	2	0	0	0	1	1
CO4	2	2	1	0	0	1	2
CO5	2	3	0	1	0	1	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs & COs

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	1	1	0	0
CO2	2	2	1	1	0	0
CO3	1	2	1	1	0	0
CO4	2	2	2	1	1	0
CO5	2	2	1	1	1	0

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSIM136	COURSE NAME BIOPYTHON	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
30	0	0	30	2	0	0	2

Course Prerequisites	Basic Knowledge of computers
Course Category	Elective
Course focus	Scientific Temperament & Employability
Rationale	Know how to develop your skills in Python. Retrieve and analyze the biological data
Course Revision/ Approval Date:	06/03/24
Course Objectives (As per Blooms' Taxonomy)	• **To Remember** the basic concepts of python • **Understand** to edit and run Python code • **To analyze and evaluate** file-processing python programs that produce output to the terminal and/or external files • **Apply** the knowledge of python to analyse the biological data • **To Create** stand-alone python programs to process biological data

Course Content (Theory)	Weightage	Contact hours
Unit 1 Execution paradigms: how the computer turns your program into something it can run (interpretation, native compilation, bytecode compilation) Basic execution and memory model (Von Neumann architecture), Version control (likely SVN and git)	**20%**	**9**
Unit 2 Imperative programming constructs: functions, if-statements, loops (for, while), switchstatements, expressions. Basic data structuring constructs: variables, arrays, strings, structs, types, and pointers, Reading and writing files	**20%**	**9**
Unit 3: Unit tests — testing small sections of code,Debugging — strategies, debuggers, common errors Profiling — figuring out what's taking so long, Make — automating compilation, Basic data structures and algorithm design techniques: Sophisticated data structures,and algorithms will be introduced, along with more difficult programming assignments.	**20%**	**9**
Unit 4: Linear data structures: arrays, lists, stacks, queues; binary search,Dictionary data structures: binary search trees including tree traversals (DFS, BFS,pre-, in-, post-order); hash tables.	**20%**	**9**

Unit 5: Heaps, heapsort,Graphs; MST, Divide and conquer, recursion Dynamic programming	**20%**	**9**

Course Outcomes	1. Develope an understanding of basic theoretical concepts of Python.
	2. Appreciate their relevance for investigating specific contemporary biological questions through the use of Biopython
	3. Understand the concepts of object-oriented programming as used in Python
	4. Learn Biopython to enhance your skills for conducting in silico experiments.
	5. Demonstrate mastery of the core concepts of Bioinformatics
Additional Information to enhance learning	Expert talk required on specific topics.

Learning Resources	
1.	**Textbook & Reference Book** 1) Python: - The Bible- 3 Manuscripts in 1 Book: -Python Programming for Beginners -Python Programming for Intermediates -Python Programming for Advanced by Maurice J Thompson 2) Learning python (5th Edition) by Mark Lutz, O'Reilly Media, Inc (2013) ISBN:9781449355739 3) Python programming for biology by Tim J. Stevens and Wayne Boucher Cambridge University Press 1st Ed. (2015) ISBN:9780511843556
2.	**Journals & Periodicals**

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Skill enhancement activities / case study	15marks
Presentation/ miscellaneous activities	10 marks
Total	**40 Marks**

Practical Marks	
	Attendance: 05 marks Practical Exam: 30 marks Viva: 10 marks Journal: 5 marks **Total: 50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	3	3	1	2	0	3
CO2	2	2	3	2	1	2
CO3	3	2	3	2	2	2
CO4	2	3	2	2	1	1
CO5	3	2	2	1	2	0

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of POs and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	2	0	0	2	0
CO2	3	2	3	1	2	2
CO3	2	3	3	1	2	2
CO4	1	3	2	1	3	3
CO5	2	2	3	2	3	0

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSMI137	COURSE NAME GENETICS	SEMESTER I

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
2	0	0	2	2	0	0	2

Course Pre-requisites	Basic knowledge of Genetics.
Course Category	Discipline specific elective
Course focus	Employability
Rationale	Studying genetics is important not only for scientific discovery but also for its real-world applications in medicine, agriculture, technology, and ethical policy development. It's a foundational discipline with widespread implications across nearly every aspect of our lives.
Course Revision/ Approval Date:	
Course Objectives (As per Blooms' Taxonomy)	1. Demonstrate a thorough understanding of genetic principles and molecular mechanisms. 2. Apply genetic concepts to practical problems in fields such as healthcare, agriculture, and biotechnology. 3. Interpret and analyze genetic data using bioinformatics tools. 4. Critically evaluate ethical issues related to genetics and biotechnology. 5. Contribute to ongoing research in genetics by designing and conducting experiments or computational studies.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Understand the Fundamentals of Genetics: Mendelian inheritance, Punnett squares, genotype/phenotype relationships, and basic genetic principles like dominance, recessiveness, and co-dominance.	**20%**	**06**
Unit 2: Genetic Variation and Evolution: Genetic diversity, mutation, genetic drift, natural selection, and evolutionary mechanisms.	**20%**	**06**
Unit 3: Population Genetics and Human Genetics: Hardy-Weinberg equilibrium and gene flow.	**20%**	**06**
Unit 4: Genetic Research and Data Analysis: Hypothesis development, experimental design, data collection, data interpretation, and scientific communication.	**20%**	**06**
Unit 5: Ethical, Legal, and Social Implications of Genetics: Ethical concerns regarding genetic testing, privacy issues, the implications of gene editing (e.g., CRISPR), genetic discrimination, and the use of genetic data.	**20%**	**06**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Objectives:		Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
CO1	Demonstrate a thorough understanding of genetic principles and molecular mechanisms.	Understand, Remember and apply	Explain, Describe, Discuss
CO2	Genetic Variation and Evolution: Genetic diversity, mutation, genetic drift, natural selection, and evolutionary mechanisms.	Analyse and apply	Apply, Practice, Interpret, Select, Correlate
CO3	Population Genetics and Human Genetics: Hardy-Weinberg equilibrium and gene flow.	Understand and Remember	Apply and Practice
CO4	Genetic Research and Data Analysis: Hypothesis development, experimental design, data collection, data interpretation, and scientific communication.	Analyse	Construct, Develop, Produce
CO5	Ethical, Legal, and Social Implications of Genetics: Ethical concerns regarding genetic testing, privacy issues, the implications of gene editing (e.g., CRISPR), genetic discrimination, and the use of genetic data.	Understand, Remember and apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: 1. Genomes" by T.A. Brown 2. Introduction to Genetic Analysis" by Anthony J. F. Griffiths, Susan R. Wessler, Sean 3. Carroll, and John Doebley. "Genetic Analysis: An Integrated Approach" by Mark F. Sanders and John A. Bowman
2	Reference Books: 1. Principles of Genetics" by D. Peter Snustad and Michael J. Simmons 2. Molecular Biology of the Gene" by James D. Watson, Tania A. Baker, and Stephen P. Bell 3. Genetics: Analysis of Genes and Genomes" by Daniel L. Hartl and Elizabeth W. Jones.
3	Journal: Nature Genetics American Journal of Human Genetics (AJHG)
4	Periodicals: Nature Reviews Genetics Genetic Engineering & Biotechnology News (GEN)
5	National Center for Biotechnology Information (NCBI) Ensembl UCSC Genome Browser

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Mapping of PSOs and CO for Agriculture Microbiology:

PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO					
CO1	1	1	2	3	0
CO2	1	1	2	3	3
CO3	1	1	1	2	2

CO4	1	1	1	1	2
CO5	1	2	2	2	1

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and CO for Agriculture Microbiology

PO	PO1	PO2	PO3	PO 4	PO5
CO					
CO1	1	2	2	2	3
CO2	1	1	2	2	3
CO3	1	1	1	2	3
CO4	1	1	1	1	2
CO5	2	2	2	2	1

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
3	4	0	45+60	3	2	0	5

COURSE CODE	**COURSE NAME**	**SEMESTER**
MSBO231	**MICROBIAL PHYSIOLOGY AND METABOLISM**	**II**

Course Pre-requisites	10+2 examination in science
Course Category	Core Compulsory
Course focus	Employability
Rationale	The course rationale acknowledges Principles of Microbial Physiology, Microbial growth, Measurement of Microbial Growth and Factors Affecting on growth, Microbial Transport and Nutrition, Microbial Photosynthesis, Microbial Energetics and Nitrogen Fixation.
Course Revision/ Approval Date:	
Course Objectives (As per Blooms' Taxonomy)	1. To impart in-depth knowledge in Principles of microbial physiology. 2. To have insight in the phases of Microbial growth, Measurement of Microbial growth and Factors affecting the growth. 3. To be informed about Microbial Transport and Nutrition. 4. To retrieve the knowledge of Process of Photosynthesis carried out by Microbes. 5. To learn about Microbial Energetics and Nitrogen Fixation.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Principles of Microbial Physiology: Nutrient transport in prokaryotic cells, Signal transduction in bacteria, Mechanism of drug resistance, Quorum sensing, Bacterial Bioluminescence, Bacterial differentiation.	**20%**	**09**
Unit 2: Microbial Growth, Measurement of Microbial Growth and Factors Affecting on Growth: Definitions of growth and generation time, measurement of microbial growth, and specific growth rate, Batch and Continuous culture, Phases and types of growth curve and its industrial application, Microbial growth in response to temperature, pH, solute and water activity, oxygen, pressure and radiation. Autotrophy - Concept, factors for, types of autotrophs, mechanisms.	**20%**	**09**
Unit 3: Microbial Transport and Nutrition: Classification of bacteria based on nutrients, Membranes of microorganisms, Ion channels, Passive and facilitated diffusion, Primary and secondary active transport, concept of uniport, symport and antiport, Group translocation and Iron uptake, Photosynthetic pigments and apparatus in bacteria, Mode of nutrition in purple sulphur bacteria, non-sulphur bacteria and green sulphur bacteria, Utilisation of light energy by halobacterium. Bio-signalling-Molecular mechanisms, signalling in bacteria- The two-component signalling mechanisms in bacterial chemotaxis. Microbial stress responses.	**20%**	**09**
Unit 4: Microbial Photosynthesis: Photosynthesis: Oxygenic and an-oxygenic microorganisms, structure of chloroplast, light reaction, photolysis of water and photophosphorylation, C3 and C4 pathway of carbon fixation. Nutritional classification of microorganisms, Energy generation in cyanobacteria, green bacteria, purple sulphur bacteria and chemolithotrophs. Lipid biosynthesis: Biosynthesis of lipids and fatty acids, triglycerol and phospholipids and their regulation.General biosynthetic pathways of amino acids, biosynthesis of purines and pyrimidines and their regulation.	**20%**	**09**
Unit 5: Microbial Energetics and Nitrogen Fixation : Concept of aerobic respiration, anaerobic respiration and fermentation. Central metabolic pathways: EMP pathway, ED pathway, PP pathway, and TCA cycle. Anaplerotic reactions, gluconeogenesis, glyoxylate cycle. Mitochondrial and bacterial electron transport. Oxidation-reduction potential and energetic of electron transport. Fermentations: alcohol fermentation, Pasteur effect, lactate and butyrate fermentation, Fermentation balances, branched versus linear fermentation pathways. Nitrogen Fixation – Physiology of nitrogen cycle. Assimilatory and dissimilatory nitrate reduction, biological nitrogen fixation. Nitrogen fixers and mechanism of nitrogen fixation.	**20%**	**09**

List of Practical

Sr.No	List of Practical	Weightage	Contact hours
1	Study and plot the growth curve of E. coli by turbidimetry and standard plate count methods.	15%	09
2	Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data.	15%	09
3	To study the diauxic growth curve of E.coli in media containing glucose, lactose and perform Beta galactosidase	15%	09

	assay.		
4	Effect of temperature, pH, concentration of salt (NaCl) and carbon (Citrate Utilisation), nitrogen sources on growth of E.coli (Turbidimetry).	15%	09
5	Isolate and identify nitrogen fixing bacteria from soil or plant roots.	15%	08
6	Pigment Extraction and Absorption Spectra of Photosynthetic Bacteria	15%	08
7	Analysis of Fermentation Products: Alcohol and Organic Acids	15%	08

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in a practical session.

Course Outcomes:		Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
CO1	On completion of this course, students should be able to understand the basics of microbial physiology.	Understand, Remember & apply	Explain, Describe, Discuss, Recall, Locate
CO2	Demonstrate an understanding of the steps involved in the growth of bacteria and factors affecting the growth phases.	Remember	Apply, Practice, Interpret, Select, Correlate
CO3	Create understanding of how microbial transport and nutrition takes place.	Remember	Compare, Classify, Select, Investigate
CO4	Critically analyse biological pathways for microbial photosynthesis.	Analyses	Construct, Develop, Produce
CO5	Demonstrate the ability to study related to bacterial growth and analysis of bacterial species in terms of factors available there in the environment.	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: 1. Kim B.H. and Gadd G.M. 2008. Bacterial physiology and metabolism. Cambridge University Press, Cambridge. 2. Gilbert H.F. 2000. Basic concepts in biochemistry: A student's survival guide. Second Edition. Mc-Graw-Hill Companies, health professions Division, New York. 3. Madigan M.T., Martinko J.M., Stahl D.A. and Calrk D.P. 2012. Brock Biology of Microorganisms. 13th ed. Pearson Education Inc. 4. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag. 5. Lehninger A. (1982). Biochemistry. Worth Publ.
2	Reference books 1. Moat A.G., Foster J.W. and Spector M.P. 2002. Microbial Physiology, 4th edition. A Johan Wiley and sons inc., publication. 2. Biochemistry by Geoffrey L. Zubay. Fourth Edition, Addison-Wesley educational publishers Inc.,2008 3. The Physiology and Biochemistry of Prokaryotes by David White. Second Edition, Oxford University Press; 2000.
3	Journal 1. Advances in Microbial Physiology 2. Microbial Physiology 3. Frontiers in Microbiology 4. Current Microbiology
4	Periodicals: 1. Microbiology today 2. Microbiologist Magazine
5	Other Electronic resources: https://onlinecourses.swayam2.ac.in/cec20_bt14/preview#:~:text=Microbial%20physiology%20and%20metabolism%20provides,three%20important%20stages%20of%20ecosystem.

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks	
Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and CO for Microbial Physiology

PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	3	3	2	2	3	1
CO2	3	1	1	2	2	2
CO3	3	2	1	1	-	-
CO4	2	2	3	-	-	3
CO5	-	-	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and CO for Microbial Physiology

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						

CO1	3	-	3	-	1	-
CO2	2	-	3	-	1	-
CO3	3	-	3	-	1	-
CO4	3	-	3	-	1	-
CO5	2	-	3	-	1	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE	COURSE NAME	SEMESTER
MSMI238	NANOSCIENCE	II

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	4	0	105	3	2	0	5

Course Prerequisites	Students should have basic knowledge about physics, chemistry and biology.
Course Category	Core Professional.
Course focus	Scientific Temperament & Employability
Rationale	Studying nanoscience allows students to explore the fundamental nature of matter at the atomic and molecular levels, which is crucial for developing next-generation technologies. The ability to manipulate matter at nano scale opens the door to innovations in medicine, materials development, energy production, and environmental sustainability. This course aims to provide that foundational understanding, enabling students to contribute meaningfully to cutting-edge research and industry developments in their respective fields.
Course Revision/ Approval Date:	08/05/2025
Course Objectives (As per Blooms' Taxonomy)	**1. Remember** Concepts of basic nanoscience. **2. Apply** To understand various nanoformulation. **3. Analyses** Interactions of nanomaterial with living systems. **4. Create** an understanding how nanoparticles developed and applied on field. **5. Understand** applications of nanomaterials..

Course Content (Theory)	Weigh tage	Contact hours
Unit 1:Introduction and classification of nanoparticles Introduction to Nanoscience, Nanotechnology and Nanobiotechnology; Classification of nanomaterials on the basis of size, shape, dimension, organic, inorganic, and carbon based nanomaterials	**20%**	**9**
Unit 2: Synthesis and properties of nanoparticles Synthesis of nanomaterials: Top down & bottom up methods; Chemical and green synthesis; Properties of nanoparticles - physical, optical, electronic, magnetic, catalytic	**20%**	**9**

Unit 3: Characterization of nanoparticles Characterization of nanoparticles by - DLS, UV-Vis spectroscopy, FTIR, XRD, XPS, SEM, TEM, XRM, AFM	**20%**	**9**
Unit 4: Applications of nanomaterials - I Medicine- diagnosis & therapy, artificial implants, tissue engineering; Food - processing & packaging; Agriculture - fertilizers & pesticides	**20%**	**9**
Unit 5: Applications of nanomaterials - II Cosmetics - formulation; Energy - nanomaterials for energy storage; Environment - remediation& waste management, Sensors – nanodevice, NEMS, MEMS; Nano – toxicity and Life Cycle Assessment	**20%**	**9**
List of practical: 1. Synthesis of metal nanoparticles by chemical route. 2. Synthesis of metal nanoparticles by hydrothermal route. 3. Green synthesis of metal nanoparticles. 4. Study optical properties of nanoparticles by using UV-Vis spectroscopy. 5. Synthesis of polymeric nanoparticles. 6. To determine the drug concentration using UV-Vis spectroscopy. 7. Antibacterial activity of drug loaded nanoparticles.		

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in practical

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
After successful completion of the above course, students will be able to:		
CO1 The objectives of this course are to build upon postgraduate level knowledge of nanoscience, nanotechnology and types of nanomaterials.	Remember	Explain, Describe, Discuss, Recall, Locate
CO2 The course shall make the students aware of various synthesis methods and properties of nanomaterials.	Apply	Apply, Practice, Interpret, Select,
CO3 The course will make the students aware of various precise methods of nanomaterial characterization.	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4 To Understand the application of nanomaterials in various fields.	Create	Develop, Produce
CO5 To Understand the application of nanomaterials in various fields.	Understand	Explain, Describe, outline, Predict, Summarise

Learning Resources

1. Textbook & Reference Book

1. Nanomaterials Chemistry by Rao C. N., A. Muller, A. K. Cheetham,, WileyVCH , 2007
2. Nanostructures and Nanomaterials, synthesis, properties and applications by Guozhong Cao, Imperial College Press, 2004
3. Nanotechnology in agriculture and food production by Jennifer Kuzma and Peter VerHage, Woodrow Wilson International, 2006
4. Bio nanotechnology by David S Goodsell, John Wiley & Sons, 2004.
5. Nano biomaterials Handbook by Balaji Sitharaman, Taylor & Francis Group, 2011.
6. Ansel‟s Pharmaceutical Dosage Forms and Drug Delivery Systems. By: Loyd V. Allen,Howard C. Anse
7. Carbon Nanotubes: Properties and Applications- Michael J. O'Connell
8. Nanotechnology Applications for Tissue Engineering, 1st Edition, Editors: Sabu Thomas, Yves Grohens, & Neethu Ninan. 2015, Elsevier
9. Edelstein A S and Cammarata R C, "Nanomaterials: Synthesis, Properties and Applications",Taylor and Francis, 2012
10. Vielstich, Handbook of fuel cells: Fuel cell technology and applications, Wiley, CRC Press, (2003).
11. Nanosensors: Physical, Chemical, and Biological by Vinod Kumar Khanna, Publisher: CRC Press.
12. Wiesner, M.R., and Bottero, J.Y. (Ed.) "Environmental Nanotechnology: Applications and Impacts of Nanomaterials" McGraw-Hill, New York. 2007
13. Nanomedicines and Nanoproducts: Applications, Disposition, and Toxicology in the Human Body
14. Application of Nanotechnology in Drug Delivery: Edited by Ali Demir Sezer, ISBN 978- 953-51- 1628- 8, 552 pages, Publisher: InTech

	15. Handbook of Nanotoxicology, Nanomedicine and Stem Cell Use in Toxicology. Saura C Sahu, Daniel A Casciano.
2.	Journals & Periodicals 1. Nanoscale 2. ACS Nano 3. Nano Today 4. Nature Nanotechnology
3	Other Electronic resources: 1) NPTEL

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	Attendance: 05 marks MCQs: 10 marks Open Book Assignment: 15 marks Article Review: 10 marks **Total: 40 Marks**
Practical Marks	Attendance: 05 marks Practical Exam: 20 marks Viva: 10 marks Journal: 10 marks Discipline: 05 Marks **Total: 50 Marks**

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	3	1	2
CO2	1	2	3	1	1
CO3	2	1	1	2	2
CO4	1	2	2	3	3
CO5	2	3	1	2	4

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and COs

PO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	1	2
CO2	3	1	2	1	1
CO3	1	2	1	2	1
CO4	2	1	2	3	3
CO5	1	2	3	2	4

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE	COURSE NAME	SEMESTER
MSMI233	BIOPROCESS ENGG. AND TECHNOLOGY	II

Teaching Scheme (Hours)				Teaching Credit			
Lecture	**Practical**	**Tutorial**	**Total Hours**	**Lecture**	**Practical**	**Tutorial**	**Total Credit**
3	4	0	45+60	3	2	0	5
Course Pre-requisites	Graduate Degree in Biological Sciences						
Course Category	Core Compulsory						
Course focus	Career in Research and Industry						
Rationale	This course is designed to provide postgraduate students with a comprehensive understanding of bioprocess engineering, particularly focusing on industrial-scale production using bioreactors and bio fermenters. With the growing relevance of biotechnology in industries such as pharmaceuticals, agriculture, food, and environmental management, this curriculum aims to impart the practical and theoretical skills necessary for designing, optimizing, and scaling up bioprocesses. Students will gain insights into the complexities of bioreactor design, process monitoring, and control mechanisms essential for the efficient production of biochemical products.						
Course Revision/ Approval Date:							
Course Objectives (As per Blooms' Taxonomy)	Understand the principles and concepts of bioprocess engineering, including cell culture techniques, microbial growth, and fermentation. Analyse different bioreactor designs and their applications in industrial-scale biotechnology. Apply quantitative methods for optimizing bioprocess parameters and maximizing product yield. Evaluate process control and monitoring methods to ensure quality and efficiency in biotechnological production. Create solutions for scaling up laboratory bioprocesses to meet industrial demands while maintaining cost-efficiency and sustainability.						

Course Content (Theory)	Weightage	Contact hours
Unit 1: Introduction to Bioprocess Engineering • Overview of bioprocessing in industrial biotechnology • Microbial growth kinetics and stoichiometry • Biocatalysts, enzyme kinetics, and applications • Industrial microorganisms and cell lines used in bioprocessing.	20%	09
Unit 2: Bioreactor Design and Analysis • Types of bioreactors: Batch, fed-batch, continuous, and perfusion • Principles of bioreactor operation and mixing • Scale-up and scale-down processes • Design considerations for industrial bioreactors	20%	09
Unit 3: Process Control and Optimization • Process parameters: pH, temperature, dissolved oxygen, and nutrient feed • Monitoring techniques and process analytical technology (PAT) • Control strategies: PID control, cascade control, and feed-forward control • Optimization techniques for yield improvement	20%	09

Unit 4: Downstream Processing and Product Recovery • Separation and purification of bioproducts • Filtration, centrifugation, precipitation, and chromatography techniques • Product quality and regulatory compliance in bioprocessing • Cost analysis and economic considerations	20%	09
Unit 5: Emerging Technologies and Sustainability in Bioprocessing • Bioprocess innovations: single-use bioreactors, continuous biomanufacturing • Sustainable practices in industrial biotechnology • Waste management and bioprocess integration • Future trends in bioprocess engineering	20%	09

List of Practical

Sr. No	List of Practical	Weightage	Contact hours
1	Microbial Growth Kinetics: Cultivation of microbial cultures to analyse growth phases and calculate specific growth rates.	20%	06
2	Enzyme Kinetics Study: Practical analysis of enzyme activity and calculation of kinetic parameters.	20%	06
3	Bioreactor Simulation: Using software for bioreactor modelling and process parameter optimization.	20%	06
4	Downstream Processing Techniques: Separation and purification using filtration and chromatography.	20%	06
5	Process Control Lab: Hands-on experience with PID control in bioreactors and monitoring real-time parameters. Industrial Visit	20%	06

Instructional Method and Pedagogy:

1. Lectures and Interactive Discussions: Establish foundational concepts.
2. Case Studies and Industrial Examples: Link theory to real-world applications.
3. Simulation Software: Use of tools like SuperPro Designer or Aspen Plus for bioprocess modelling.

4. Laboratory Practical's: Provide hands-on experience to reinforce theoretical knowledge.
5. Industry Guest Lectures and Panel Discussions: Gain insights from industry professionals on current trends.

Course Outcomes:	**Blooms' Taxonomy Domain**	**Blooms' Taxonomy Sub Domain**
CO1 Understand the principles and concepts of bioprocess engineering, including cell culture techniques, microbial growth, and fermentation.	Remembering & Understanding	Explain, Describe, Discuss, Recall, Locate
CO2 Analyse different bioreactor designs and their applications in industrial-scale biotechnology.	Analysing	Apply, Practice, Interpret, Select, Correlate
CO3 Apply quantitative methods for optimizing bioprocess parameters and maximizing product yield.	Apply	Compare, Classify, Select, Investigate
CO4 Evaluate process control and monitoring methods to ensure quality and efficiency in biotechnological production.	Evaluate	Construct, Develop, Produce
CO5 Create solutions for scaling up laboratory bioprocesses to meet industrial demands while maintaining cost-efficiency and sustainability.	Create	Explain, Describe, outline, Predict, Summarize

sr. No.	**Learning Resources**
1	**Textbook:** 1. Textbook of Bioprocess Engineering by Shuler, Michael L., and Fikret Kargi 2. Bioprocess Engineering: Basic Concepts by Pauline M. Doran 3. Principles of Fermentation Technology by Peter F. Stanbury, Allan Whitaker, and Stephen J. Hall

2	**Reference books** 1. Biochemical Engineering Fundamentals by James E. Bailey and David F. Ollis 2. Bioreactor Design and Product Yield Optimization by Mukesh Doble and Anil Kumar Kruthiventi
3	**Journal** Biotechnology and Bioengineering Journal of Industrial Microbiology & Biotechnology Biochemical Engineering Journal Trends in Biotechnology Applied Microbiology and Biotechnology
4	**Periodicals:**
5	**Other Electronic resources:** 1. Bioprocessing for Biotech Products (FutureLearn) – Covers bioprocessing principles, with a focus on drug development and industrial applications. 2. Introduction to Biomanufacturing and Bioprocessing (Coursera) – Offered by the University of California, this course is useful for students focusing on scalable bioprocessing techniques. 3. Biochemical Engineering (NPTEL) – An Indian platform course that addresses enzyme kinetics, bioreactor design, and applications in industrial biotechnology. **4.** Biotechnology and Bioprocessing (edX) – Offered by MIT, this course covers advanced concepts in bioprocessing, including scale-up and optimization techniques.

<table>
<tr><th>Evaluation Scheme</th><th>Total Marks</th></tr>
<tr><td>Theory: Mid semester Marks</td><td>20 marks</td></tr>
<tr><td>Theory: End Semester Marks</td><td>40 marks</td></tr>
<tr><td>Theory: Continuous Evaluation Component Marks</td><td><table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>MCQs</td><td>10 marks</td></tr>
<tr><td>Open Book Assignment</td><td>15 marks</td></tr>
<tr><td>Article Review</td><td>10 marks</td></tr>
<tr><td>Total</td><td>40 Marks</td></tr>
</table></td></tr>
<tr><td>Practical Marks</td><td><table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>Practical Exam</td><td>20 marks</td></tr>
<tr><td>Viva</td><td>10 marks</td></tr>
<tr><td>Journal</td><td>10 marks</td></tr>
<tr><td>Discipline</td><td>05 marks</td></tr>
<tr><td>Total</td><td>50 Marks</td></tr>
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Mapping of PSOs and CO

PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	3	3	2	2	3	1
CO2	3	1	1	2	2	2
CO3	3	2	1	1	-	-
CO4	2	2	3	-	-	3
CO5	-	-	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and CO

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	-	3	-	1	-
CO2	2	-	3	-	1	-
CO3	3	-	3	-	1	-
CO4	3	-	3	-	1	-
CO5	2	-	3	-	1	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE	COURSE NAME	SEMESTER
MSBO232	RESEARCH METHODOLOGY & IPR	II

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
2	0	0	30	2	0	0	2

Course Pre-requisites	Graduate Degree in Biological Sciences
Course Category	Elective
Course focus	Understanding research processes, methodologies, and intellectual property rights fundamentals.
Rationale	The subject "Research Methodology & IPR" equips students with essential skills for systematic research, data analysis, and intellectual property protection, fostering innovation, academic integrity, and effective utilization of research outcomes.
Course Revision/ Approval Date:	
Course Objectives **(As per Blooms' Taxonomy**	1. **Understand** the importance of research, its ethical considerations, and distinguish between qualitative, quantitative, and mixed methods. 2. **Analyse** research questions, define problems, and **apply** suitable experimental and non-experimental designs. 3. **Evaluate** sampling techniques, address errors, and **develop** strategies for data collection and statistical analysis. 4. **Explain** types of IPR and assess their role in protecting innovations and traditional knowledge. 5. **Understand** international frameworks (GATT, WTO, WIPO, TRIPS) to the impact of IPR on research and biotechnology.

Course Content (Theory)	Weightage	Contact hours
Unit I: Introduction to Research Methodology: Definition and importance of research, Types of research (qualitative, quantitative, methods), The research process (formulating research questions, hypothesis, etc.). Ethical considerations in research.	**20%**	**06**
Unit II: Research Problems & Research Design: Defining research problems. Important concepts in research design, dependent and independent variables, research hypothesis, experimental and non-experimental hypothesis.	**20%**	**06**
Unit III: Sampling Techniques: Sampling theory, types of sampling, Steps in sampling, Sample size. Data Collection Methods andAnalysis.	**20%**	**06**
Unit IV: Introduction To Intellectual Property: Types of IP: patents, trademarks, copyright, industrial design, protection of new GMOs.	**20%**	**06**
Unit V: Frameworks of IPR: International Framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies.	**20%**	**06**

Instructional Method and Pedagogy:

Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments
Practical exercises are designed to understand the theory as taught in the classroom.
Hands on in a practical session.

Course Outcomes:	Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
CO1 Explain the importance of research and differentiate between types of research methodologies (qualitative, quantitative, mixed methods). Discuss the research process and ethical considerations involved in conducting research.	Understand, Remember & Apply	Explain, Describe, Discuss, Recall, Locate
CO2 Identify and define research problems and formulate hypotheses. Apply steps and techniques to create effective research designs, including experimental, quasi-experimental, and non-experimental designs.	Remember	Apply, Practice, Interpret, Select, Correlate
CO3 Compare and classify sampling techniques, analyse the steps in sampling, and differentiate between sampling and non-sampling errors. Investigate appropriate methods for data collection and statistical analysis in research.	Remember	Compare, Classify, Select, Investigate

CO4	Analyse and construct frameworks for intellectual property rights (IPR), including patents, trademarks, copyrights, industrial designs, and protection of GMOs. Develop an understanding of international frameworks like GATT, WTO, WIPO, and TRIPS.	Analyse	Construct, Develop, Produce
CO5	Summarize the role of intellectual property in research and development, particularly in biotechnology, and predict its impact through case studies. Explain the historical and contemporary significance of IPR in fostering innovation.	Understand, Remember & Apply	Explain, Describe, Outline, Predict, Summarize

Sr. No.	Learning Resources
1.	**Textbook:** 1. On Being a Scientist: A Guide to Responsible Conduct Research. (2009). Washington, D.C.: National Academies Press. 2. Gopen, G. D., & Smith, J.A. The Science of Scientific Writing. American Scientist, 78 (Nov-Dec 1990), 550-558.
2.	**Reference Books:** 1.Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press. 2.Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India.
3.	**Journal:** 1. International Journal of Research Methodology 2. International Journal of Science and Research Methodology
4.	**Periodicals:** Journal of Research Practice
5.	**Other Electronic resources:** Movies: Naturally Obsessed: The Making of a Scientist

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Mapping of PSOs and CO for Research Methodology & IPR

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	3	2	2	1	1	-
CO2	3	3	3	2	1	-
CO3	3	3	3	2	-	-
CO4	2	2	2	3	3	3
CO5	2	2	3	2	3	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and CO for Research Methodology & IPR

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	-	-	2	-
CO2	3	3	2	-	-	-
CO3	3	2	3	-	-	-
CO4	2	2	2	2	3	2
CO5	2	2	-	2	3	3

COURSE CODE	COURSE NAME	SEMESTER
MSMI236	ADVANCE BIOPYTHON	II

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
2	0	0	2	2	0	0	2

Course Pre-requisites	10+2 examination in science
Course Category	Discipline-specific elective
Course focus	Employability
Rationale	Learn Coding
Course Revision/ Approval Date:	
Course Objectives (As per Blooms' Taxonomy)	Ability to create Series
	Data frames and apply various operations.
	Visualize data using relevant graphs.
	Understand libraries like NumPy, Pandas and Matplotlib

Course Content (Theory)	Weightage	Contact hours
properties of data objects, pass arrays to functions, return values, functions using libraries: mathematical, and string functions. · File		

Unit 2: Introduction to libraries in Python, Data Handling using Pandas -Introduction to Python libraries- Pandas, Matplotlib, NumPy.	20%	6
Unit 3: Data structures in Pandas - Series and Data Frames. Series: Creation of Series from – ND array, dictionary, scalar value; mathematical operations; Head and Tail functions; Selection, Indexing and Slicing	20%	6
Unit 4: Data Visualization, Purpose of plotting; drawing and saving following types of plots using Matplotlib – line plot, bar graph, histogram, customizing plots: adding label, title, and legend in plots.	20%	6
Unit 1: Functions: scope, parameter passing, mutable/immutable handling: open and close a file, read, write, and append to a file,	20%	6

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Outcomes:	**Blooms' Taxonomy Domain**	**Blooms' Taxonomy Sub Domain**
After successful completion of the above course, students will be able to: **CO1:** Understand and Utilize Core Python Libraries	Remember, Understanding	Describe
CO2: Gain proficiency in using Panda's data structures, specifically Series and Data Frames, to organize, manipulate, and analyse structured data efficiently.	Remember, Understanding, apply	Explain
CO3: Perform Data Manipulation with Series and Data Frames	Understanding Analyse	Explain
CO4: Implement Data Importing and Exporting:	Understanding	Describe
CO5: Visualize Data Using Matplotlib:	Remember, Understanding	Describe

Evaluation Scheme	Total Marks = 150
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Research Paper Review	10 marks
Total	40 Marks

Practical Marks

Attendance	05 marks
Practical Exam	30 marks
Viva	10 marks
Journal	05 marks
Total	50 Marks

Learning Resources

1. Reference books:

1) Python: - The Bible- 3 Manuscripts in 1 Book: -Python Programming for Beginners -Python

Programming for Intermediates -Python Programming for Advanced by Maurice J Thompson

2) Learning python (5th Edition) by Mark Lutz, O' Reilly Media, Inc (2013).

ISBN:9781449355739

3) Python programming for biology by Tim J. Stevens and Wayne Boucher.

Cambridge University.Press 1st Ed. (2015) ISBN:9780511843556

2	**Journal & Periodicals:** 1. Briefings of Bioinformatics 2. Bioinformatics 3. Journal of Computational Biology **4. BMC Bioinformatics**
3	**Other Electronic resources:** NPTEL, Coursera, MH Education

Mapping of PSOs and COs

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	-	1	2	1	1	-
CO2	1	2	2	2	3	-
CO3	2	-	3	1	2	1
CO4	2	3	2	-	2	2
CO5	2	1	-	1	-	2

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and COs

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	-	2	2	1
CO2	3	2	1	2	1	-
CO3	2	-	-	1	2	1
CO4	2	1	2	3	2	2
CO5	-	1	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE	COURSE NAME	SEMESTER
MSMI321	PROJECT PROPOSAL PREPARATION	III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	0	0	45	3	0	0	3

Course Pre-requisites	Graduate Degree in Biological Sciences
Course Category	Core Compulsory
Course focus	Employability in Industry and career in Research
Rationale	The course in Project proposal preparation expands the understanding and ideology of Post Graduate students on the preparation of project proposal aspects. With a deep understanding and importance on the basic aspects and overview of Project proposal, various steps in the preparation of Project proposal, proposal evaluation, various Government funding agencies in India and Gujarat
Course Revision/ Approval Date:	
Course Objectives **(As per Blooms' Taxonomy)**	1. To impart in-depth knowledge about the Overview about Proposal writing and Tips for writing an effective Proposal. 2. To have insight types of various proposal and Proposal Outline. 3. To be informed about the various steps for writing a proposal. 4. To retrieve the knowledge of various points pertaining to the Evaluation of Proposal. 5. To learn in brief about the various National level and State level funding agencies.

Course Content (Theory)	Weightage	Contact hours
Unit I: Overview: Overview about the Project proposal writing; Preamble of Proposal writing; Basic details required for Proposal writing; Tips for writing an effective Proposal – Clarity and conciseness- Objectives – Innovative approaches – Budget – Team Qualification; Significance and importance of effective Proposal writing.	**20%**	**09**
Unit II: Types of Proposal & Outlines: Types: Solicited Proposals – Unsolicited Proposals – Internal Proposals – Research Proposals- Network Project Proposals; Event (Seminar/ Workshop) Proposals; Outline: Cover page, Executive summary, Table of contents, Introduction, Objectives, Methodology / Approach, Budget, Teams Qualification, Outcome/Deliverables, Conclusion.	**20%**	**09**
Unit III: Steps for writing a proposal: Steps: Executive summary, Background, National and International Status, Goals/ Objectives, Methodology, Innovativeness of the Proposal; Expected outcome, Time line and Schedule; Infrastructure resources; Budget, Investigators background;	**20%**	**09**
Unit IV: Evaluation of Proposals: Scientific merit – Clarity of Hypothesis – Attainable goals – Relevance and ability to implement approaches – Innovativeness of the proposed idea – Background of Investigator; Panel Evaluation: Individual evaluation – Consensus group – Panel review – Final decision;	**20%**	**09**
Unit V: Funding agencies: Brief Overview about Indian Funding agencies – Overview about Anusandhan National Research Foundation (ANRF); Indian Council of Medical Research (ICMR); Department of Science Technology; Gujarat – Gujarat Council for Science and Technology (GUJCOST); Gujarat State Biotechnology Mission (GSBTM); Knowledge Consortium Gujarat – SHODH scheme (PhD Scholars in Gujarat)	**20%**	**09**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in a practical session.

Course Outcomes:		Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
CO1	On completion of this course, students should be able to understand the basics and brief overview about proposal Writing and tips for writing an effective proposal.	Understand, Remember & apply	Explain, Describe, Discuss, Recall, Locate

CO2	Demonstrate and understanding the types of proposal and Brief outline about overview of proposal writing	Remember	Apply, Practice, Interpret, Select, Correlate
CO3	Demonstrate and understanding the various steps in the writing the proposal.	Remember	Compare, Classify, Select, Investigate
CO4	Demonstrate and understanding the various phases in the Evaluation of submitted proposal.	Analyses	Construct, Develop, Produce
CO5	Demonstrate the various National and State level funding Agencies and impart their role in the Development of Science and Technology.	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: 1. Gurumani, N. 2011. Biological Research Methodology for Biological Sciences; MJP Publishers, Chennai. 2. Kothari, C.R., 2023. Research methodology – Methods and Techniques, New Age International Publishers, New Delhi.
2	Reference books 1. Laake, :P., Benestad, B.B. Olsen, B.R., 2004. Research Methodology in the Medical and Biological Sciences, Elsevier Publications.
3	Journal 1. BMC Medical Research Methodology 2. International Journal of Research Methodology
4	Periodicals: 1. University News 2. Current Science
5	Other Electronic resources: https://libguides.jsu.edu/bioresearch/design https://research.com/research/how-to-write-research-methodology https://www.kantata.com/blog/article/8-tips-for-writing-a-project-proposal

<table>
<tr><th>Evaluation Scheme</th><th>Total Marks</th></tr>
<tr><td>Theory: Mid semester Marks</td><td>20 marks</td></tr>
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<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>MCQs</td><td>10 marks</td></tr>
<tr><td>Open Book Assignment</td><td>15 marks</td></tr>
<tr><td>Article Review</td><td>10 marks</td></tr>
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<tr><td>Practical Marks</td><td>
<table>
<tr><td>Attendance</td><td>05 marks</td></tr>
<tr><td>Practical Exam</td><td>20 marks</td></tr>
<tr><td>Viva</td><td>10 marks</td></tr>
<tr><td>Journal</td><td>10 marks</td></tr>
<tr><td>Discipline</td><td>05 marks</td></tr>
<tr><td>Total</td><td>50 Marks</td></tr>
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Mapping of PSOs and CO for Microbial Physiology

PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	3	3	2	2	3	1
CO2	3	1	1	2	2	2
CO3	3	2	1	1	-	-
CO4	2	2	3	-	-	3
CO5	-	-	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and CO for Microbial Physiology

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	-	3	-	1	-
CO2	2	-	3	-	1	-
CO3	3	-	3	-	1	-
CO4	3	-	3	-	1	-
CO5	2	-	3	-	1	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE	COURSE NAME	SEMESTER
MSMI322	EMERGING TECHNOLOGIES	III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	4	0	45+60	3	2	0	5

Course Pre-requisites	Graduate degree in Biological Sciences
Course Category	Core Compulsory
Course focus	Career in Research and Industry
Rationale	Broad-based in nature encompassing several new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences. Emerging technologies enhance research precision, exploring areas like epigenetics, proteomics, and microbial diversity.
Course Revision/ Approval Date:	
Course Objectives **(As per Blooms' Taxonomy)**	1. **Remember** Concepts of new technologies 2. **Apply** understanding Experimental approaches 3. **Analyses** appreciate current-day research tool-kit. 4. **Create** an understanding how interactions network develops 5. **Understand** applications both scientific and industrial

Course Content (Theory)	Weightage	Contact hours
Unit 1: Microscopy Theory: Optical microscopy methods Basic Microscopy: Light Microscopy- lenses and microscopes, resolution: Rayleigh's approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence and fluorescence microscopy: what is fluorescence, what makes a molecule fluorescent, fluorescence microscope; optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording colour; three CCD elements with dichroic beams platters, boosting the signal. Advanced Microscopy: Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers &solid-state, primary beam splitter; beam scanning, pinhole and signal channel configurations, detectors; pixels and voxels; contrast, spatial sampling: temporal sampling: signal-to noise ratio, multichannel images. nonlinear microscopy: multiphoton microscopy; principles of two-photon fluorescence, advantages two-photon excitation, tandem scanning (spinning disk) microscopes, deconvolving confocal images; image processing, three-dimensional reconstruction; advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; BeyondtheDiffractionLimit:StimulatedEmissionDepletion(STED),SuperResolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM)	**20%**	**09**
Unit 2: Mass spectroscopy & AA Theory: Mass spectroscopy Ionization techniques; mass analysers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LCMS; Phosphor proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry, AAS and its applications in life sciences	**20%**	**09**
Unit 3: System & Structural Biology Theory: Systems biology High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modelling and designing testable predictions. Structural biology X-ray diffraction methods, solution &solid-state NMR, cryo-electron microscopy, small angle X-ray scattering, atomic force microscopy.	**20%**	**09**

Unit 4: CRISPR technology Theory: CRISPR-CAS History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.	**20%**	**09**
Unit 5: NANOBODIES Theory: NANOBODIES Introduction to nanobodies, combining nanobody with phage-display method for development of antibody against native proteins, nanobody as a tool for protein structure-function studies, use of nanobodies for molecular imaging, catabolic antibodies using nanobodies.	**20%**	**09**
Course Content (Theory)	**Weightage**	**Contact hours**

List of Practical

Sr. No	List of Practical	Weightage	Contact hours
1	To study the working and principle of fluorescent microscopy/ inverted microscopy	20%	06
2	Demonstration of Atomic Absorption Spectroscopy	20%	06
3	Protein structure prediction and Bioinformatics analysis	20%	06
4	Demonstration of RT-PCR/ Cloning/ Designing Guide RNA using bioinformatic tools	20%	06
5	Demonstration of ELISA/HPLC/GC	20%	06

Instructional Method and Pedagogy:

Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on and demonstration in a practical session.

Course Outcomes:		Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
CO1	Students will come to know the new technologies that current experimental researchers are employing to probe complex questions in life-sciences	Remember	Explain, Describe, Discuss, Recall, Locate

CO2	Enhance research capabilities in students by knowing the new principles so as to appreciate current-day research tool-kit better	Apply	Apply, Practice, Interpret, Select, Correlate
CO3	Understanding the need for Technologies	Analyses and Evaluation	Compare, Classify, Select, Investigate
CO4	Understanding the advanced technologies.	Create	Construct, Develop, Produce
CO5	Applications of Emerging Technologies	Understand	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: 1. Campbell, I.D. (2012). Biophysical Techniques. Oxford: Oxford University Press. 2. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). Methods in Molecular Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press. 3. Phillips, R., Kondev, J., & Theriot, J.(2009). Physical Biology of the Cell. New York: Garland Science. 4. Nelson, P.C., Radosavljević, M.,&Bromberg, S.(2004). Biological Physics: Energy, Information, Life. New York: W.H.Freeman.

2	Reference books & articles 1. Huang, B., Bates, M., & Zhuang, X. (2009). Super-Resolution Fluorescence Microscopy. Annual Review of Biochemistry, 78(1),993-1016.doi:10.1146/annurev. biochem.77.061906.092014. 2. Mohanraju, P.,Makarova, K. S., Zetsche, B., Zhang, F.,Koonin, E. V.,& Oost, J. V. (2016).Diverse Evolutionary Roots and Mechanistic Variations of the CRISPR-Cas Systems. Science, 353(6299). doi:10.1126/science.aad5147. 3. Lander, E.(2016).The Heroes of CRISPR. Cell, 164(1-2), 18-28.doi:10.1016/j. cell.2015.12.041. 4. Ledford, H.(2016).TheUnsungHeroesofCRISPR.Nature,535(7612),342-344. doi:10.1038/535342a. 5. Jinek,M., Chylinski, K., Fonfara,I., Hauer,M.,Doudna,J.A., &Charpentier,E. (2012). A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity. Science, 337(6096), 816-821.doi:10.1126/science.1225829. 6. Hamers-Casterman,C.,Atarhouch,T.,Muyldermans,S.,Robinson,G.,Hammers, C., Songa, E. B., Hammers, R. (1993). Naturally Occurring Antibodies Devoid of Light Chains. Nature, 363(6428), 446-448.doi:10.1038/363446a0. 7. Sidhu, S. S., & Koide, S. (2007). Phage Display for Engineering and Analysing Protein Interaction Interfaces. Current Opinion in Structural Biology, 17(4), 481-487. doi:10.1016/j.sbi.2007.08.007. 8. Steyaert, J., & Kobilka, B. K.(2011). Nanobody Stabilization of G Protein-Coupled Receptor Conformational States. Current Opinionin Structural Biology, 21(4), 567-572. doi:10.1016/j.sbi.2011.06.011. 9. Vincke, C., & Muyldermans, S. (2012). Introduction to Heavy Chain Antibodies and Derived Nanobodies. Single Domain Antibodies, 15-26. doi:10.1007/978-1-61779-968- 6_2. 10. Verheesen, P.,& Laeremans, T.(2012). Selection by Phage Display of Single Domain Antibodies Specific to Antigens in their Native Conformation. Single Domain Antibodies, 81-104.doi:10.1007/978-1-61779-968-6_6. 11. Li,J.,Xia,L.,Su,Y.,Liu,H.,Xia,X.,Lu,Q.Reheman,K.(2012).Molecular Imprint of Enzyme Active Site by Camel Nanobodies. Journal of Biological Chemistry J. Biol. Chem., 287(17), 13713-13721.doi:10.1074/jbc.m111.336370. 12. Sohier,J.,Laurent,C.,Chevigné,A.,Pardon,E.,Srinivasan,V.,Wernery,U.Galleni, M. (2013). Allosteric Inhibition of VIM Metallo-β-Lactamases by a Camelid Nanobody. Biochemical Journal, 450(3), 477-486. doi:10.1042/bj20121305. 13. Chakravarty, R., Goel, S., & Cai, W.(2014). Nanobody: The “Magic Bullet” for Molecular Imaging?Theranostics,4(4),386-398.doi:10.7150/thno.8006.
3	Journal 1. JBC, 2. Science, Plos biology
4	Periodicals: Current science
5	Other Electronic resources: 1) MH Education 2) NPTEL

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<tr><td>Viva</td><td>10 marks</td></tr>
<tr><td>Journal</td><td>05 marks</td></tr>
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Mapping of PSOs and CO for Emerging Technologies

PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	1	-	2	1	1	-
CO2	1	3	2	2	-	-
CO3	1	-	-	1	2	1
CO4	2	3	2	-	2	2
CO5	2	1	-	1	-	2

Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and CO for Emerging Technologies

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	2	-	2	2	1
CO2	-	1	1	2	-	-
CO3	2	-	-	1	2	1
CO4	2	1	2	3	2	2
CO5	-	1	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSMI323	COURSE NAME PHARMACEUTICAL MICROBIOLOGY	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	4	0	45+60	3	2	0	5

Course Pre-requisites	B.Sc. Microbiology
Course Category	Discipline specific core
Course focus	Employability
Rationale	The course rationale serves several critical purposes, providing students with essential knowledge and skills that are vital for their future careers. This will provide the understanding of Microbial Contamination and Control, Sterilization and Aseptic Techniques, Regulatory policies in Drug Development and Manufacturing, Public Health and Safety, Research and Development Skills, and Antibiotics and Resistance.
Course Revision/ Approval Date:	
Course Objectives (As per Blooms' Taxonomy)	1. To emphasize principles involved in Chemotherapeutic agents, their mechanism of action and to impart the knowledge about Drug Resista 2. To understand the antimicrobial chemicals, preservation of medicines using antimicrobial agents and their efficacy. 3. To impart the knowledge of GMP and GLP of pharmaceutical laboratories and to learn the quality control protocols for pharma products. 4. To analyse spoilage, sterilization of pharmaceutical products and pharmacokinetics. 5. To design and understand the regulatory policies for the development of pharmaceutical products.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Chemotherapeutic agents History and development of chemotherapeutic agent, Properties of antimicrobial agents (Chemical Disinfectants, Antiseptics and Preservatives), Antibiotics; Natural and Synthetic (Properties of drugs and their target microbial species), Antifungal drugs, Antiviral drugs, Antiprotozoal drugs Antitumor substances. Mechanism of action of antibiotics (Inhibitors of cell wall synthesis, Nucleic acid synthesis inhibition and Protein Synthesis Inhibitor). Factors influencing drug effectiveness. Drug resistance: Mechanism of antibiotic resistance, Concept of Multiple Drug resistance (MDR).	**25%**	**09**
Unit 2: Antimicrobial Agents Chemical Disinfectants, Antiseptics and Preservatives and their industrial significance. Factors affecting choice of antimicrobial agent. Phenols, Alcohols, Aldehydes, Halogens, Heavy metals, Quaternary Ammonium compounds, Sterilizing gases, Biguanides, Peroxide and Peroxygen compounds and other antimicrobials. Preservation of medicines using antimicrobial agents. Efficacy of antimicrobial agent-Phenol coefficient method.	**15%**	**09**
Unit 3: GMP and Quality control Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry. Regulatory aspects of quality control. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization) Chemical and biological indicators. Design and layout of sterile product manufacturing unit. (Designing of Microbiology laboratory), Safety in microbiology laboratory.	**20%**	**09**
Unit 4: Microbial production and Spoilage of pharmaceutical Products Microbial contamination and spoilage of pharmaceutical products (sterile injectables, non-injectables, ophthalmic preparations and implants) and their sterilization. Manufacturing procedures and in process control of pharmaceuticals. Other pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase). New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines. Vaccine clinical trials.	**25%**	**09**
Unit 5: Regulatory practices, biosensors and applications in Pharmaceuticals Financing R&D capital and market outlook. IP, BP, USP. Government regulatory practices and policies, FDA perspective. Reimbursement of drugs and biologicals, legislative perspective. Rational drug design. Immobilization procedures for pharmaceutical applications (liposomes). Macromolecular, cellular and synthetic drug carriers.	**15%**	**09**

List of Practical

Sr.No	List of Practical	Weightage	Contact hours/week
1	Bioassay of chloremphenicol by plate assay method or turbidimetric Assay method.	20%	4
2	Sterility testing by *Bacillus stearothermophilus*	10%	4
3	Sampling of pharmaceuticals for microbial contamination and load (syrups, suspensions, creams and ointments, ophthalmic preparations).	10%	4
4	Determination of antimicrobial activity of a chemical compound (Phenol, resorcinol, thymol, formaldehyde) to that of phenol under Standardized experimental conditions.	20%	4
5	Determination of MIC valued for antimicrobial chemicals.	10%	4

6	Testing for antibiotic/drug sensitivity/resistance	10%	4
7	Efficacy testing of preservatives like parabens	10%	4
8	Sterility testing of pharmaceutical products by membrane filtration method as per Indian Pharmacopoeia (IP).	10%	4

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Objectives:		**Blooms' Taxonomy Domain**	**Blooms' Taxonomy Sub Domain**
CO1	On completion of this course, students should be able to understand the action of antibiotics which can be formulated to treat or inhibit the various diseases.	Understand, Remember& apply	Explain, Describe, Discuss
CO2	On completion of this course, students should be able to distinguish the differences among antimicrobial chemical. They should be able to demonstrate the efficacy of preservatives.	Analyse	Apply, Practice, Interpret, Select, Correlate
CO3	On completion of this course, students should be able to apply the GMPs and GLPs of pharmaceutical labs with the understanding of quality control.	Understand and Remember	Apply and Practice
CO4	On completion of this course, students should be able to analyse the spoilage and sterilization of pharmaceutical products.	Analyses	Construct, Develop, Produce
CO5	On completion of this course, students should be able to demonstrate the regulatory guidelines for the formulation of pharma products.	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: • Gad, S. C., (2007), Handbook of Pharmaceutical Biotechnology. Wiley-Interscience, New Jersey, (ISBN: 978-0-470-25958-0). • Denyer, S. P. and Baird, R. M., (2008), Guide to microbiological control inpharmaceuticals and medical devices. 2nd Edition, CRC Press, Boca Raton, (ISBN: 9781444330632)
2	Reference Books: • Pharmaceutical Microbiology – Edt. by W.B.Hugo & A.D.Russell Sixth edition. Blackwell scientific Publications. • Analytical Microbiology –Edt by Frederick Kavanagh Volume I & II. Academic Press New York. • Quinolinone antimicrobial agents – Edt. by David C. Hooper, John S.Wolfson. ASM Washington DC. • Quality control in the Pharmaceutical Industry - Edt. by Murray S.Cooper Vol.2. Academic Press New York. • Good Manufacturing Practices for Pharmaceuticals Second Edition, by Sydney H.Willig, Murray M.Tuckerman, William S.Hitchings IV. Mercel Dekker NC New York. • Quality Assurance in Microbiology by Rajesh Bhatia, Rattan lal Ihhpunjani. CBS Publishers & Distributors, New Delhi.
3	Journal: • Frontiers in Pharmacology • Journal of controlled release
4	Periodicals: • International Journal of Pharmaceutics (IJP) • Journal of Pharmacy & Pharmaceutical Sciences
5	Other Electronic resources: NCBI, ENSEMBL, VISTA, UCSC etc.

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks	

Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and CO for Pharmaceutical Microbiology

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	1	-	2	2	-	1
CO2	1	-	2	-	3	-
CO3	3	3	3	2	2	-
CO4	3	3	3	-	-	3
CO5	3	1	3	3	3	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and CO for Pharmaceutical Microbiology

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

CO3	3	2	3	2	-	2
CO4	3	2	3	-	-	3
CO5	3	3	-	3	3	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSMI324	COURSE NAME ENVIRONMENTAL MICROBIOLOGY	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	4	0	45+60	3	2	0	5

Course Pre-requisites	10+2 examination in science
Course Category	Specialization
Course focus	Employability
Rationale	This course provides a general introduction to the diverse roles of microorganisms in natural and artificial environments. It will cover topics including: significance, history and challenges of environmental microbiology, microbial biogeochemistry, microorganisms and biotic interactions, applied microbial ecology and bioremediation, applied environmental microbiology.
Course Revision/ Approval Date:	
Course Objectives (As per Blooms' Taxonomy)	1. To introduce environmental microbiology and its scope. 2. To understand the role of microbes in biogeochemistry. 3. To understand various modes of biotic interaction of microbes. 4. To get insights of the role of microbes in pollution control. 5. To get acquainted with applied aspects of environmental microbiology.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Significance, History, and Challenges of Environmental Microbiology: History of environmental microbiology; Core concepts of environmental microbiology; Complexity of our world; importance of environmental microbiology; interdisciplinary aspect; future avenues in environmental microbiology; microbiology of soil, water and air.	**20%**	**09**
Unit 2: Microbial Biogeochemistry: Mineral connections: the roles of inorganic elements in life processes; Elemental biogeochemical cycles: concepts and physiological processes; Cellular mechanisms of microbial biogeochemical pathways; Nitrogen cycle: General aspects of nitrogen cycling; Ammonification and ammonia assimilation; Nitrification; Nitrate reduction and Nitrogen fixation.	**20%**	**09**
Unit 3: Microorganisms and Biotic Interactions: Interaction: A Key Aspect of Living; parasitism; predation; antibiosis; competition; Cometabolism; mutualism; cooperation; Commensalism; Horizontal Gene Transfer	**20%**	**09**
Unit 4: Applied Microbial Ecology and Bioremediation: Prerequisite to understand the concept of microbe based bioremediation; Xenobiotics and bioaccumulation; Microorganisms as Bioremediation Agents: Bio stimulation, Bioaugmentation, Rhizostimulation, Bioleaching, and Bio immobilization.	**20%**	**09**
Unit 5: Applied Environmental Microbiology: Other organisms as microbial habitats: ecological relationships; Microbial residents of plants and humans; Biodegradation and bioremediation; Biofilms; Evolution of catabolic pathways for organic contaminants; Environmental biotechnology: overview and case studies; antibiotic resistance.	**20%**	**09**

List of Practicals

Sr.No	List of Practical	Weightage	Contact hours
1	Bioremediation of inorganic pollutants and phytoremediation of metals	10%	06
2	Characterization of waste water: a. Physical: odour, colour, turbidity, temperature, salinity b. Chemical: acidity, alkalinity, sulphate, copper	10%	06
3	Analysis of drinking water by MTT and MFT a. Biological characterization: BOD & COD	10%	06
4	Estimation of phosphatase activity of soil: acid and alkaline	10%	06
5	Isolation of probiotic culture from various sources a. Evaluation and efficacy of probiotic culture	10%	06
6	Phosphate Solubilization by Soil Microorganisms	10%	06
7	Co-culture Experiment to Study Mutualism (e.g., Algae–Bacteria or	10%	06

	Fungi–Bacteria)		
8	Bioaugmentation/Biostimulation in Soil Microcosms	10%	06
9	Detection of Antibiotic Resistance in Environmental Isolates	10%	06
10	Microbial Analysis of Compost and Vermicompost Systems	10%	06

EInstructional Method and Pedagogy:

Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in a practical session.

Course Outcomes:		Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
CO1	On completion of this course, students should be able to understand the basics of environmental microbiology.	Understand, Remember & apply	Explain, Describe, Discuss, Recall, Locate
CO2	Demonstrate an understanding of the steps involved in the biogeochemical cycles.	Remember	Apply, Practice, Interpret, Select, Correlate
CO3	Create understanding of how microbes interact with biotic factors.	Remember	Compare, Classify, Select, Investigate
CO4	Analyze the process of bioremediation, factors affecting the process and creating the understanding of applied microbial ecology.	Analyses	Construct, Develop, Produce
CO5	Demonstrate the ability to study related to applied environmental microbiology in terms of factors available there in the environment.	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: 1. K Viyaya Ramesh (2019) Environmental Microbiology, MJB Publishers 2. R.G. Buckley (2016) Environmental Microbiology, CBS Publishers & Distributors 3. Eugene L. Madsen (2008) Environmental Microbiology From genomes to biogeochemistry, John Wiley & Sons, Inc. 4. Jean-Claude Bertrand, Pierre Caumette, Philippe Lebaron, Robert Matheron, Philippe Normand, Télesphore Sime-Ngando (2015) Environmental Microbiology: Fundamentals and Applications: Microbial Ecology; Springer Netherlands 5. Ian L Pepper; Charles P Gerba; Terry J Gentry (2014) Environmental microbiology, Elsevier/Academic Press 6. Roger Tim Haug (2019) Lessons in Environmental Microbiology, CRC Press Taylor & Francis Group
2	Reference books 1. I.L. Pepper and C.P. Gerba (2004) Environmental Microbiology A Laboratory Manual, Elsevier/Academic Press 2. Christon J. Hurst (eds.) (2016) The Mechanistic Benefits of Microbial Symbionts, Springer International Publishing 3. Hurst, Christon J.; Crawford, Ronald L.; Garland, Jay L.; Lipson, David A.; Mills, Aaron L.; Stetzenbach, Linda D. (Eds.) (2007) Manual of Environmental Microbiology, American Society for Microbiology 4. Myung-Bo Kim eds. (2008) Progress in Environmental Microbiology, Nova Biomedical Books New York 5. Moo-Young, M., Anderson, W. A., & Chakrabarty, A. M. (Eds.). (2013). Environmental biotechnology: principles and applications. Springer Science & Business Media.
3	Journal 1. Applied and Environmental Microbiology 2. Critical Reviews in Microbiology 3. Nature Reviews Microbiology 4. Nature Microbiology 5. Microbiology 6. BMC Microbiology 7. Trends in Microbiology
4	Periodicals: 1. Gavrilescu, Maria. "Environmental biotechnology: achievements, opportunities and challenges." Dynamic biochemistry, process biotechnology and molecular biology 4.1 (2010): 1-36. 2. Verstraete, Willy, and Eva Top. "Holistic environmental biotechnology." Microbial control of pollution. (1992): 1-17. 3. Grommen, Roeland, and Willy Verstraete. "Environmental biotechnology: the ongoing quest." Journal of Biotechnology 98.1 (2002): 113-123. 4. Michalak, Izabela. "The application of seaweeds in environmental biotechnology." Advances in Botanical Research. Vol. 95. Academic Press, 2020. 85-111. 5. Kalogerakis, Nicolas, et al. "The role of environmental biotechnology in exploring, exploiting, monitoring, preserving, protecting and decontaminating the marine environment." New biotechnology 32.1 (2015): 157-167. 6. Yong, J. J. Y., Chew, K. W., Khoo, K. S., Show, P. L., & Chang, J. S. (2020). Prospects and development of algal-bacterial biotechnology in environmental management and protection. Biotechnology Advances, 107684. 7. Pileggi, M., Pileggi, S. A., & Sadowsky, M. J. (2020). Herbicide bioremediation: from strains to bacterial communities. Heliyon, 6(12), e05767.

5	Other Electronic resources: ● https://sfam.org.uk/ ● https://www.isme-microbes.org/ ● https://www.asmscience.org/VisualLibrary ● https://microbe.net/resources/microbiology-web-resources/ ● https://www.epa.gov/ ● https://microbiologyonline.org/teachers/resources

Evaluation Scheme	**Total Marks**
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Practical Marks	

Attendance	05 marks
Practical Exam	20 marks
Viva	10 marks
Journal	10 marks
Discipline	05 marks
Total	**50 Marks**

Mapping of PSOs and CO for Environmental Microbiology

PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	3	3	2	2	3	1
CO2	3	1	1	2	2	2
CO3	3	2	1	1	-	-
CO4	2	2	3	-	-	3
CO5	-	-	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and CO for Environmental Microbiology

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	-	3	-	1	-
CO2	2	-	3	-	1	-
CO3	3	-	3	-	1	-
CO4	3	-	3	-	1	-
CO5	2	-	3	-	1	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSMI325	COURSE NAME AGRICULTURE MICROBIOLOGY	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	0	0	3	3	0	0	3

Course Pre-requisites	Basic knowledge of agriculture microbiology.
Course Category	Discipline specific elective
Course focus	Employability
Rationale	Agricultural Microbiology lies in the growing need for advanced scientific knowledge to address key challenges in agriculture, such as food security, environmental sustainability, and the efficient use of natural resources. Agricultural microbiology plays a pivotal role in improving agricultural productivity, enhancing soil health, and combating plant diseases, while maintaining ecological balance.
Course Revision/ Approval Date:	
Course Objectives (As per Blooms' Taxonomy)	1. To emphasize principles involved in role of microbes present in soil and carry out various biogeochemical cycles. 2. To understand the role of microbes in plant growth and killing the plant pathogens: Biofertilizers (Biogeochemical cycle-Nitrogen fixation) and Biopesticides. 3. To impart the knowledge of Microbial transformation in soil and production of organic manures. 4. To understand the various plant diseases caused by bacteria, fungi and other agents. To understand the methods to control them by biological techniques. 5. To understand the molecular plant microbe interactions. The study of designing new techniques to recycle agricultural wastes.

Course Content (Theory)	Weightage	Contact hours
Unit 1: Soil microbial ecology: Soil biota, types of organisms in different soils; Soil microbial biomass; Factors influencing the soil microflora. Different Agriculturally important beneficial microorganisms – free living, symbiotic (rhizobial, mycorrhizal, actinorhizal), associative and endophytic nitrogen fixers including cyanobacteria. **Microbial interactions:** Different interfaces of interactions - Plant-microbe, microbe-microbe, soil microbe, soil-plant-microbe interactions leading to symbiotic, associative, endophytic and pathogenic interactions, unculturable soil biota. Plant growth promoting rhizobacteria (PGPR). Mechanism of plant growth promotion by PGPR.	**20%**	**09**
Unit 2: Introduction to biofertilizers: definition, types of biofertilizers; Characteristic features of the following biofertilizer organisms: Azospirillium, Azotobacter, Bacillus, Pseudomonas, Rhizobium, Frankia, Anabaena and Nostoc . Mechanisms of action of different bio-inoculants for plant growth. Significance of biofertilizers. Mass scale production and quality control of bio-inoculants. Biofertilizer inoculation and microbial communities in the soil. **Biological nitrogen fixation:** Biochemistry of N_2 fixation, nif operon, mechanism of nitrogen fixation. Symbiotic nitrogen fixation: Rhizobium-Legume association, Actinorhizal associations, contribution of symbiotic nitrogen fixation. Denitrification. Phosphate solubilization and mobilization. Mycorrhizae- Ecto and endomycorrhizae, VAM and their importance in agriculture.	**20%**	**09**
Unit 3: Microbial transformations: of nitrogen, phosphorus, sulphur, iron and manganese in soil. Biochemical composition and biodegradation of soil organic matter and crop residues. Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures. Microbial degradation of polymers: lignin, cellulose, hemicelluloses. Factors affecting the degradation of organic matter. **Organic manures:** Preparation, properties, and use in crop production, nutrient enriched compost, green manure; Composting, vermicomposting	**20%**	**09**
Unit 4: Some important plant diseases and their etiological studies: Diseases of field, vegetable, orchard and plantation crops and their control; causes and classification of plant diseases; principles of biological control of diseases. Methods to exclude pathogens from host- Quarantines and Inspections, Crop certification, Evasion or avoidance of pathogen, use of pathogen-free propagating material, pathogen-free seeds and vegetative propagating materials. Plant immunization; Direct protection; Integrated control, Biopesticides – *Bacillus thuringiensis*, *B. sphaericus*, *B. popilliae*, *Pseudomonas syringae*. **Biocontrol** – Concept, types, mode of action, uses and practical constraints & applications of biocontrol agents. Biocontrol agent for sustainable agriculture. Different types of biocontrol agents. Biopesticides and bioherbicides, Biopesticides- classification, advantages. Major biopesticides based on bacteria, viruses & fungi (*Bacillus thuringiensis* (Bt) toxin, Boverin, DeVine, Collego).	**20%**	**09**
Unit 5: Molecular plant microbe-interactions: Cell signalling, Quorum sensing, and Biofilm formation. Invasion of plant tissue: Resistance mechanisms against attack by plant pathogens. Molecular detection of pathogens. Integrated pest management-concepts and components; host plant resistance-biological control of insect pests; Recycling of agricultural wastes – Microbiology of biogas, bioethanol and value added products. Mushroom cultivation and vermicomposting.	**20%**	**09**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in classroom. Hands on in practical session.

Course Objectives:		Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
CO1	On completion of this course, students should be able to emphasize principles involved in role of microbes present in soil and carry out various biogeochemical cycles.	Understand, Remember& apply	Explain, Describe, Discuss
CO2	On completion of this course, students should be able to understand the role of microbes in plant growth and killing the plant pathogens: Biofertilizers (Biogeochemical cycle-Nitrogen fixation) and Biopesticides.	Analyse	Apply, Practice, Interpret, Select, Correlate
CO3	On completion of this course, students should be able to impart the knowledge of Microbial transformation in soil and production of organic manures.	Understand and Remember	Apply and Practice
CO4	On completion of this course, students should be able to understand the various plant diseases caused by bacteria, fungi and other agents. They should also able to understand the methods to control them by biological techniques.	Analyses	Construct, Develop, Produce
CO5	On completion of this course, students should be able to understand the molecular plant microbe interactions and able to design new techniques to recycle agricultural wastes.	Understand, Remember& apply	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: • Kaushik, B. D. (2007). Principles of agricultural microbiology. Kalyani Publishers. • Sharma, H. D. (2013). Agricultural microbiology. Rastogi Publications.
2	Reference Books: • Paul, E. A. (2014). Soil microbiology, ecology, and biochemistry (4th ed.). Academic Press. https://doi.org/10.1016/B978-0-12-415955-6.00001-7 • Glick, B. R. (2014). Plant growth-promoting rhizobacteria: Applications and perspectives. Springer. https://doi.org/10.1007/978-3-319-10929-4 • Caruso, G., & Lo, F. (Eds.). (2021). Advances in plant and agricultural microbiology. Elsevier. https://doi.org/10.1016/B978-0-12-819965-2.00001-7 • Martínez-Romero, E., & Arguelles-Arias, A. (2016). Microbial diversity in the agriculture ecosystem. Springer. https://doi.org/10.1007/978-3-319-32060-7 • Singh, D. P., & Gupta, V. K. (Eds.). (2019). *Microorganisms in sustainable agriculture and biotechnology*. Springer. https://doi.org/10.1007/978-3-319-92643-0 • Widmer, F., & Mohn, W. W. (2017). Microbial ecology of the rhizosphere (1st ed.). Springer. https://doi.org/10.1007/978-3-319-45579-5
3	Journal: • FEMS Microbiology Ecology • Applied and Environmental Microbiology
4	Periodicals: • Soil Biology and Biochemistry • Biological Control
5	Other Electronic resources: Agricultural Research Service (ARS) – USDA, National Agricultural Library (NAL) – USDA, Science Direct, PubMed.

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Mapping of PSOs and CO for Agriculture Microbiology:

PO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						

CO1	1	-	2	2	-	1
CO2	1	-	2	-	3	-
CO3	3	3	3	2	2	-
CO4	3	3	3	-	-	3
CO5	3	1	3	3	3	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and CO for Agriculture Microbiology

PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO						
CO1	3	2	3	-	-	2
CO2	2	3	3	-	-	1
CO3	3	2	3	2	-	2
CO4	3	2	3	-	-	3
CO5	3	3	-	3	3	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSBO326	COURSE NAME FOOD TECHNOLOGY	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	0	0	45	3	0	0	3

Course Pre-requisites	Graduate Degree in Biological Sciences
Course Category	Elective
Course focus	Employability as well as Entrepreneurship in Food Industry
Rationale	1.Interdisciplinary Integration: Combines microbiology, biotechnology, and engineering to innovate in food production and safety. 2. Food Safety and Microbial Control: Applies microbiological expertise to control pathogens and improve food safety. 3. Development of Functional Foods: Uses biotechnology to create health-enhancing food products with bioactive compounds. 4. Innovative Food Processing: Explores advanced processing techniques like fermentation and enzyme applications for better food quality and sustainability. 5. Sustainability: Focuses on eco-friendly food production, reducing waste, and enhancing sustainability through biotechnological innovations. 6. Career Opportunities: Opens career paths in food industry R&D, product development, food safety, and quality control. 7. Nutritional Enhancement: Enhances food nutritional quality to promote public health and address dietary needs. 8. Societal Impact: Contributes solutions to global challenges like food security, malnutrition, and obesity.
Course Revision/ Approval Date:	
Course Objectives (As per Blooms' Taxonomy)	**1. Knowledge (Remembering):** Recall fundamental concepts in food microbiology, food preservation techniques, and the role of microorganisms in food production. (Identify, List, Define) **2. Comprehension (Understanding)**: Explain the biochemical processes involved in food fermentation, spoilage, and the role of microbes in these processes (Explain, Describe, Summarize) **3. Application (Applying):** Apply microbiological and biotechnological principles to solve practical food safety and preservation issues (Apply, Demonstrate, Use) **4. Analysis (Analyzing)**: Analyze the impact of food processing techniques (e.g., pasteurization, fermentation) on food safety, quality, and nutritional value (Analyze, Compare, Differentiate.) **5. Synthesis (Creating)**: Design innovative food products or preservation methods using modern biotechnological tools and microbial applications (Design, Create, Develop.) **6. Evaluation (Evaluating)**: Evaluate the effectiveness of different food preservation methods and the role of genetically modified organisms in food production (Evaluate, Assess, Critique)

Course Content (Theory)	Weightage	Contact hours
Unit I: Food Processing Techniques Introduction: importance, conventional methods, difference between processing and preservation. a. Thermal processing – pasteurisation, commercial sterilisation (12 D), sterilisation, UHT. b. Non – thermal processing – use of light and sound, high pressure, pulsed electric field, irradiation. c. Drying and dehydration – tunnel, tray, vacuum, spray, freeze drying. d. Fermentation / enzyme technology – different products.	**20%**	**09**
Unit II: Chemical and Microbial Aspect a. Composition – proximate, nutritional b. Additives / Preservatives – types, roles, functions. c. Spoilage – different food categories. d. Pathogens f. Probiotics.	**20%**	**09**
Unit III: Preservation and Packaging a. Principles of preservation – physical, chemical, biological. b. Traditional methods – drying, fermentation, pickling (in oil, Fermented) salting, smoking, canning c. Packaging – materials, migration, CAP controlled atmospheric packaging, MAP (modified), active packaging, edible films, biodegradable fils, smart packaging, sustainable packaging.	**20%**	**09**
Unit IV: Quality and Safety a. Evaluation of quality – physical, chemical, microbiological, sensory. b. Laws and Regulations – national FSSAI, international CODEX, ISO. c. HACCP. d. Food recall e. Misbranding and adulteration.	**20%**	**09**
Unit V: Future trends a. Sustainable food systems – vertical farming, lab grown meat. b. Alternative Protein sources – proteins from algae, meat alternatives. c. Personalised diet and health d. Reduction in food wastage, byproducts from food waste e. AI and IoT in food technology, 3D printing of food.	**20%**	**09**

Instructional Method and Pedagogy:
Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments Practical exercises are designed to understand the theory as taught in the classroom. Hands on in a practical session.

Course Outcomes:		Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
CO1	Students will be able to recall key principles of food microbiology, food safety, and food preservation techniques.	Understand, Remember	Explain, Describe, Discuss, Recall, Locate
CO2	Students will demonstrate an understanding of the biochemical and microbiological processes involved in food fermentation, spoilage, and preservation.	Understand, Remember	Apply, Practice, Interpret, Select, Correlate
CO3	Students will be able to apply microbiological techniques to solve food safety challenges and design appropriate food preservation strategies.	Apply, Analyses	Compare, Classify, Select, Investigate
CO4	Students will analyze various food processing methods, understanding their effects on food quality, safety, and nutritional value.	Apply, Analyses	Construct, Develop, Produce
CO5	Students will be able to design innovative food products or preservation systems by integrating biotechnological and microbiological knowledge. And Students will evaluate the effectiveness of different food technologies and their potential impacts on food sustainability, quality, and safety.	Understand, apply, Create,	Explain, Describe, outline, Predict, Summarize

Learning Resources	
1	Textbook: 1. Modern Food Microbiology, 4th edition by J.M. Jay, Springer, 2006. 2. Food Microbiology by M.R. Adams, Royal Society of Chemistry, 2008. 3. Frazier, W.C. and Westhoff, D.C. (2013). Food Microbiology. 5th Ed. Tata McGraw Hill. 4. Food Science and Technology by Geoffrey Campbell-Platt, John Wiley & Sons, 2017 5. Handbook of Food Engineering Edited By Dennis R. Heldman, Daryl B. Lund, Cristina Sabliov 6.
	Reference books 1. Doyle, M.P. and Buchanan, R.L. (2012), Food Microbiology, ASM Press, Washington. 2. Handbook of Food Preservation By M.Shafi ur Rahman, 2nd Edition CR Press, Taylor and Fransis Group 3. Food Science and Technology by Gordon W. Fuller 4. Food Process Engineering and Technology by Zeki Berk 5. Introduction to Food Science and Technology By Geoffrey Campbell-Platt
3	Journal 1. Journal of Food Science and Technology 2. International Journal of Food Science and Technology
4.	Electronic resources:

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	

Attendance	05 marks
MCQs	10 marks
Open Book Assignment	15 marks
Article Review	10 marks
Total	**40 Marks**

Mapping of PSOs and CO

PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO						
CO1	3	3	2	2	3	1
CO2	3	1	1	2	2	2
CO3	3	2	1	1	-	-

CO4	2	2	3	-	-	3
CO5	-	-	-	2	-	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

Mapping of PO and CO for Microbial Physiology

PO	PO1	PO2	PO3	PO4	PO5	PO6
CO						
CO1	3	-	3	-	1	-
CO2	2	-	3	-	1	-
CO3	3	-	3	-	1	-
CO4	3	-	3	-	1	-
CO5	2	-	3	-	1	-

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None

COURSE CODE MSMI327	COURSE NAME ECOLOGY AND EVOLUTION	SEMESTER III

Teaching Scheme (Hours)				Teaching Credit			
Lecture	Practical	Tutorial	Total Hours	Lecture	Practical	Tutorial	Total Credit
3	00	0	45	3	0	0	3

Course Pre-requisites	Students should have basic understanding about the ecosystem and environment
Course Category	**Elective**
Course focus	Employability
Rationale	To understand various aspects related to ecology and evolution
Course Revision/ Approval Date:	
Course Objectives (As per Blooms' Taxonomy)	1. Remember: To gain knowledge on the concept of habitat and population dynamics 2. Apply: To understand theories and principles of population genetics and prey-predator interactions 3. Analyses: To learn major events happening during the evolutionary time-scale 4. Apply: To understand population growth curve and evolution. 5. Understand: To examine the evolutionary basis of altruism as well as behaviour interactions

Course Content (Theory)	Weightage	Contact hours
Unit 1: Population Ecology and Niche Theory Concept of habitat and niche, niche width and overlap, fundamental and realized niche, resource partitioning, character displacement, population growth curves, population regulation, life history strategies (r and K selection), concept of metapopulation.	**20%**	**10**
Unit 2: Community Ecology and Biogeography Community assembly, organization and succession, species-area relationships, Types of interactions, ecophysiology (physiological adaptations to abiotic environment), prey predator interactions (Lotka-Voltera equation), theory of island biogeography.	**20%**	**08**
Unit 3: Molecular and Evolutionary Origins of Life Origin of basic biological molecules, Concept of Oparin and Haldane, Experiment of Miller, Evolutionary time scale- Eras, periods and epoch, Major events in the evolutionary time scale, Human Evolution.	**20%**	**09**
Unit 4: Evolutionary Mechanisms and Population Genetics Population growth rates (density dependent/independent), Gene frequency: Hardy-Weinberg Law, migration and random genetic drift, Adaptive radiation, Isolating mechanisms, Speciation: Allopatricity and Sympatricity, Co-Evolution	**20%**	**09**
Unit 5: Behavioural Ecology and Neurobiology Altruism and evolution-Group selection, Kin selection, Reciprocal altruism, Neural basis of learning, memory, cognition, sleep and arousal, biological clocks; Development of behaviour, Mating systems.	**20%**	**09**
Instructional Method and Pedagogy: Audio-Visual Lectures, Quizzes, Debates, Project works, Case studies, and Assignments.		

Course Objectives:		Blooms' Taxonomy Domain	Blooms' Taxonomy Sub Domain
CO1	Understand the concepts of habitat and ecological niche, Population dynamics and selection strategies.	Understand, analyse	Explain, Describe, Discuss
CO2	Understand and evaluate community assembly and its interactions along with theory of island biogeography and its relevance to species distribution.	Understand, Evaluate and Apply	Practice, Interpret, Correlate
CO3	Explore and understand origin of life and major events in the evolutionary time scale.	Apply, Remember	Explain, Describe
CO4	Analyse and understand population growth and explore concept of adaptive radiation as well as co-evolution.	Understand, Remember and Apply	Create and Analyse
CO5	Examine the evolutionary basis of altruism and how behaviour develops in individuals through genetic and environmental interactions.	Apply, Understand & Remember	Explain, Describe, Summarize

Learning Resources	
1	Reference Books 1. Odum, E. P., & Barrett, G. W. (2005). *Fundamentals of ecology* (5th ed.). Brooks/Cole 2. Smith, R. L., & Smith, T. M. (2015). *Elements of ecology* (9th ed.). Pearson 3. Maynard Smith, J. (1993). *The theory of evolution* (Canto ed.). Cambridge University Press 4. Stiling, P. (2015). *Ecology: Theories and applications* (5th ed.). Pearson 5. Ridley, M. (2004). *Evolution* (3rd ed.). Blackwell Publishing 6. E.S. Morton and B. Stutchbury.2001. *Behavioural ecology*. Academic Press 7. Douglas J. Futuyma, 1998. *Evolutionary Biology*, Sinauer Associates, Inc. Sunderland
2	Journals and Periodicals: 1. Nature Ecology and Evolution 2. Frontiers in Ecology and the Environment 3. Global Ecology and Biogeography 4. Journal of Ecology
3	Other Electronic Sources 1. NPTEL

Evaluation Scheme	Total Marks
Theory: Mid semester Marks	20 marks
Theory: End Semester Marks	40 marks
Theory: Continuous Evaluation Component Marks	Attendance 05 marks MCQs 10 marks Open Book Assignment 15 marks Article Review 10 marks

	Total **40 Marks**

Mapping of PSOs and COs

PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	2	1	2	1	1	1
CO2	1	3	2	2	1	1
CO3	2	1	1	1	2	1
CO4	3	3	2	2	2	2
CO5	2	2	1	1	1	3

Mapping of POs and COs

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	2	2	1
CO2	2	3	1	2	1	1
CO3	2	1	2	1	2	1
CO4	2	3	2	2	2	3
CO5	1	2	1	2	3	3

1: Slight (low); 2: Moderate (Medium); 3: Substantial (High); 0 None