Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science andCommerce, Baramati

(Empowered Autonomous)

Two Year M. Sc. Degree Program

in Microbiology

(Faculty of Science and Technology)

Choice-Based Credit System Syllabus

(2026 Pattern) (As Per NEP 2020)

M. Sc. Microbiology

Semester I

To be implemented from Academic Year 2026-2027

Preamble:

Overall picture of student trends (before undergraduate studies) in selecting courses is very typical; most of the science students aim at professional courses, particularly leading to studies in Engineering. Comparatively a smaller number of students opts for degrees in Biosciences. For several years now, the first preference of students desiring to enter the field of Life Sciences has been Microbiology, and for last 2 to 3 years it has shifted partly to Biotechnology courses.Both these disciplines viz. Microbiology and Biotechnology deal with overlapping interests. Microbial sciences focus more on study of the microbial world (this limitation needs to be corrected!) While Biotechnology focuses more on application of mammalian systems. The main theme of teaching these courses, however, remains the same i.e., application of basic principles of Life Science to develop into technology. Modern biology combines the principlesof chemistry and biological sciences (molecular and cellular biology, genetics, and immunology) with technological disciplines (engineering, computer science) to produce goodsand services and for environmental management. Tools of molecular biology play an important role in preparation of an engineered clone, a recombinant or a genetically manipulated organism (GMO). The Board of Studies in Microbiology has identified the following thrust areas and prospective plans for syllabi reforms at postgraduate level:

Microbial Technology – includes application of bacteria, fungi, protozoa and viruses in traditional (food, dairy, wine, antibiotics, fermentation, etc.) and biotechnological industries.

Human health – includes pathogenic micro-organisms (bacterial, viral, protozoan and fungal), therapeutics and pharmaceutical approach towards diseases, diagnostics, vaccine developments, epidemiological characterization of diseases, gene therapy, etc.

Agriculture – includes biofertilizers and biocontrol, ecology and geomicrobiology.

Environment – includes cleaner processes that produce less waste and use less energy and water in such industrial sectors as chemicals, pulp and paper, textiles and dyes, food, energy, and metals and minerals, harnessing microbial utilities avoiding the use of caustic chemicals, bioremediation and bioprospecting

Microbial diversity – includes collecting information of diversity, exploration and utilization of diversity to identify and harvest biomolecules for human health improvisation, micro-organisms from extreme environments, Archaebacteria, etc.

Research in life-sciences – includes research tools like immunology and molecular biology, developmental biology, evolution, stem cell research, etc. To enrich students' knowledge and

train them in the above-mentioned areas; we feel certain topics in the present syllabus need to be supplemented and strengthened by inclusion of few additional topics. Areas that need to be introduced in syllabi have been identified as:

- Eukaryotic cellular organization
- Eukaryotic gene expression e.g., yeast genetics
- Determinants of microbial pathogenicity
- Immunopathology, immunopharmacology and cancer biology
- Protein stability, conformation and folding
- Over-expression of recombinant proteins
- Biocontrol
- Bioinformatics
- Molecular tools for characterization, identification of bacteria
- Possible utilization of microbial population from extreme environments

In addition, we feel that the students should be well acquainted with research methodology which includes different skill developments in scientific writing, data handling and processing,development of research ideas and planning / designing of research projects. The skill sets thusevolved will help the students in academic and applied research

Introduction:

The syllabi till today had been sufficient to cater for the needs of students for building up theircareers in industry and research. However, with the changing scenario at local and global level, we feel that the syllabus orientation should be altered to keep pace with developments in the education sector. The need of the hour is proper syllabi that emphasize on teaching of technological as well as the administrative aspects of modern biology. Theory supplemented with extensive laboratory expertise will help these students, to avail these opportunities. Both these aspects i.e., theory and more of practical needs to stressed, such that a post-graduate student can start work directly in applied fields (Industry or institutions), without any additionaltraining. Thus, the college itself will be developing the trained and skilled man-power. We evenfind a lack of trained teachers who can share their experiences on different aspects in microbiology. And we plan to restructure the syllabus in this viewpoint. The restructured syllabus will combine the principles of chemistry and biological sciences (molecular and cell biology, genetics, immunology and analytical tools) with technological disciplines to producegoods and services and for environmental management.

Eligibility

B. Sc. with Principle subject Microbiology.

Duration of Course – Two years.

External students – There shall be no external students.

Program Specific Outcomes (PSOs)

PSO1: Microbial Diversity and Physiology

Demonstrate comprehensive knowledge of microbial diversity, structure, physiology, metabolism, and molecular biology relevant to modern microbiological sciences.

PSO2: Biomolecular Structure and Function

Apply biochemical and molecular principles to understand the structure, properties, and functions of biomolecules such as proteins, nucleic acids, carbohydrates, and lipids.

PSO3: Laboratory Techniques in Microbiology and Biochemistry

Perform essential microbiological and biochemical laboratory techniques including spectroscopy, electrophoresis, chromatography, and nanoparticle synthesis for the analysis of biological molecules.

PSO4: Instrumentation and Analytical Skills

Utilize modern laboratory instruments and analytical tools in microbiology for qualitative and quantitative estimation of biomolecules.

PSO5: Bioinformatics and Data Analysis

Apply computational tools, bioinformatics databases, and statistical methods for analysis and interpretation of biological data.

PSO6: Research Methodology and Experimental Design

Design and conduct microbiological experiments using appropriate research methodologies, sampling techniques, and experimental designs.

PSO7: Scientific Communication and Research Skills

Demonstrate effective scientific communication through research writing, literature review, presentations, and preparation of research proposals.

PSO8: Laboratory Safety and Ethics

Adhere to Good Laboratory Practices (GLP), biosafety guidelines, and ethical standards in microbiological research and laboratory practices.

PSO9: Interdisciplinary Applications of Microbiology

Apply microbiological knowledge in interdisciplinary areas such as biotechnology, environmental microbiology, medical microbiology, and industrial microbiology.

PSO10: Employability and Entrepreneurship Skills

Develop professional skills that support employability, entrepreneurship, and innovation in sectors such as pharmaceuticals, biotechnology, food technology, environmental management, and research laboratories.

Credit distribution structure for Two Years PG as per National Education Policy (2026 Pattern)
(M.Sc.)

PG Program for First Year														
Level	**Sem.**	**Major (MD)**	**Major (Ele)**				**RM**	**OJT**	**RP**					**Cum.Cr.**
6.0	I	8(T)+4 (P)/ 14(T)	2(T)+2 (T/P)/ 4(T)	--	--	---	4 (RM)(T)	--	--	--	--	--	--	**20/ 22**
	II	8(T)+4 (P) 14(T)	2(T)+2 (T/P) 4(T)	--	0	---	0	4 (OJT)		0	0	0	0	**20/ 22**
Cum. Cr. For PG Diploma		**24/28**	**8**				**4**	**4**						**40/44**
Exit option: PG Diploma (40-44 Credits) after Three Year UG Degree														
PG Program for Second Year														
6.5	III	8(T)+4(P)/ 14(T)	2(T)+2 (T/P)/ 4(T)						4 (RP)		0	0	0	**20/ 22**
	IV	8(T)+2(P)/ 12(T)	2(T)+2 (T/P)/ 4(T)						6 (RP)		0	0	0	**20/ 22**
Cum. Cr. For PG Degree		**22/26**	**8**						**10**					**40/44**
Cum. Cr. For 2 Yr. PG Degree		**46/54**	**16**				**4**	**4**	**10**					**80/88**
Exit option: PG Degree (80-88 Credits) after Three Year UG Degree														

Abbreviations: Yr.: Year; Sem.: Semester; MD: Mandatory, Ele: Electives, OJT: On Job Training: Internship/ Apprenticeship; FP: Field projects; RM: Research Methodology; Research Project: RP; Cumulative Credits: Cum. Cr., T: Theory, P: Practical

Anekant Education Society's

Tuljaram Chaturchand college of Arts, Science and commerce, Baramati,

Empowered Autonomous, NAAC A ++

Department of Microbiology

Course and Credit structure for

M.Sc. –I Microbiology NEP-2020 (2026 Pattern)

M.Sc. I MICROBIOLOGY NEP 2020 (2026 PATTERN)						
Level	**Semester**	**Course type**	**Course code**	**Title of course**	**Theory/practical**	**No of credit**
6.0	I	Major mandatory	MIB-501-MRM	Instrumentation in Microbiology	Theory	4
			MIB-502-MRM	Biochemistry	Theory	4
			MIB-503-MRM	Quantitative Biology	Theory	2
			MIB-504-MRM	Practical Course I	Practical	2
			MIB-505-MRM	Practical Course II	Practical	2
		Major (elective)	MIB-506-MJE(A)	Microbial taxonomy	Theory (any one)	2
			MIB-506-MJE(B)	Bioinformatics		
			MIB-507-MJE(A)	Practical course III (A)	Practical (any one)	2
			MIB-507-MJE(B)	Practical course III (B)		
		Research methodology	MIB-508-RM	Research methodology	Theory	4
	TOTAL CREDIT SEMESTER I					**22**
6.0	II	Major mandatory	MIB-551-MRM	Molecular Biology	Theory	4
			MIB-552-MRM	Microbial Metabolism	Theory	4
			MIB-553-MRM	Techniques in instrumentation	Theory	2
			MIB-554-MRM	Practical course IV	Practical	2
			MIB-555-MRM	Practical course V	Practical	2
		Major (elective)	MIB-556-MJE(A)	Bioremediation and biomass utilization	Theory (any one)	2
			MIB-556-MJE(B)	Ecology		
			MIB-557-MJE(A)	Practical course VI (A)	Practical (any one)	2
			MIB-557-MJE(B)	Practical Course VI (B)		
		On Job Training	MIB-558-OJT	On Job Training	Practical	4
	TOTAL CREDIT SEMESTER II					22
CUMULATIVE CREDITS FOR PG DIPLOMA -IAND II						**22+22=44**

(CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from June, 2026)

Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: I**
Course Type	**: Major Mandatory Theory**
Course Name	**: Instrumentation in Microbiology**
Course Code	**: MIB-501-MRM**
No. of Lectures	**: 60**
No. of Credits	**: 04**

Course Objectives

1. To introduce the fundamental principles of chromatography including partition coefficient, resolution, and column efficiency.
2. To provide knowledge of different chromatographic techniques such as gel filtration, ion-exchange, affinity, gas chromatography, and HPLC.
3. To develop understanding of electromagnetic spectrum and molecular transitions in spectroscopy.
4. To explain the principles, instrumentation, and applications of UV-Visible, fluorescence, infrared, and atomic spectroscopy.
5. To impart knowledge of electrophoretic techniques including AGE, Native PAGE, SDS-PAGE, and isoelectric focusing.
6. To familiarize students with centrifugation techniques such as ultracentrifugation, differential, isopycnic, and rate zonal centrifugation.
7. To create awareness about industrial biosafety, laminar airflow systems, biosafety cabinets, and HVAC systems for laboratory and industrial environments.

Course Outcomes

After successful completion of this course, students will be able to:

CO1: Explain the principles and parameters of chromatography including partition coefficient, resolution, and Van Deemter equation.
CO2: Describe the working principles, instrumentation, and applications of different chromatographic techniques such as gel filtration, ion-exchange, affinity chromatography, GC, and HPLC.
CO3: Understand the fundamentals of spectroscopy including electromagnetic spectrum and molecular transitions.
CO4: Interpret spectroscopic data obtained from UV-Visible, fluorescence, infrared, and atomic spectroscopy.
CO5: Apply electrophoresis techniques for separation and analysis of biomolecules.
CO6: Explain and utilize centrifugation techniques for separation of cellular components and biomolecules.
CO7: Demonstrate knowledge of industrial biosafety practices including laminar airflow, biosafety cabinets, and HVAC systems.

Credit No.	Topic and learning point	Teaching hour
Credit I	**Chromatography**	**15**

	Partition Coefficient, Selectivity, Resolution, Column Efficiency, Van Deemter equation, Interpretation of chromatograms	2
	Principle, components of instrument, operation and application of-	
	Gel filtration chromatography	3
	Ion-exchange Chromatography	3
	Affinity chromatography	2
	Gas chromatography	2
	High Performance Liquid Chromatography	3
Credit II	**Spectroscopy**	**15**
	Electromagnetic spectrum, atomic orbitals, Molecular orbitals, Electronic, Rotational and Vibrational transitions in spectroscopy, Interpretation of spectra	3
	UV/Visible spectroscopy	3
	Fluorescence spectroscopy	3
	Infrared spectroscopy	3
	Atomic spectroscopy	3
Credit III	**Electrophoresis and Centrifugation**	**15**
	Agarose Gel Electrophoresis	2
	Native Polyacrylamide Gel Electrophoresis	2
	Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis	3
	Isoelectric focusing	2
	Ultra-centrifugation	2
	Differential centrifugation	2
	Isopycnic and Rate zonal centrifugation	2
Credit IV	**Industrial Biosafety and Environment Regulation**	**15**
	Laminar air flow: Aseptic area, Design, Types, operating principle	5
	Biosafety cabinet: Types, working and principle	4
	HVAC System	
	1. Heating	2
	2. Cooling	2
	3. Ventilation and Air conditioning	2

References

1. Principles of Instrumental Analysis – Skoog, D. A., Holler, F. J., & Crouch, S. R. (2014). *Principles of Instrumental Analysis* (6th ed.). Cengage Learning.
2. Introduction to Modern Liquid Chromatography – Snyder, L. R., Kirkland, J. J., & Dolan, J. W. (2010). *Introduction to Modern Liquid Chromatography* (3rd ed.). Wiley.
3. Chromatography Concepts and Contrasts – Miller, J. M. (2005). *Chromatography: Concepts and Contrasts* (2nd ed.). Wiley-Interscience.
4. Principles and Techniques of Biochemistry and Molecular Biology – Wilson, K., & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology* (7th ed.). Cambridge University Press.
5. Biophysical Chemistry – Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical Chemistry* (Vol. I–III). W. H. Freeman.

6. Spectrometric Identification of Organic Compounds – Silverstein, R. M., Webster, F. X., Kiemle, D. J., & Bryce, D. L. (2014). *Spectrometric Identification of Organic Compounds* (8th ed.). Wiley.
7. Gel Electrophoresis of Proteins – Hames, B. D., & Rickwood, D. (1998). *Gel Electrophoresis of Proteins: A Practical Approach* (3rd ed.). Oxford University Press.
8. Gel Electrophoresis of Nucleic Acids – Rickwood, D., & Hames, B. D. (1990). *Gel Electrophoresis of Nucleic Acids: A Practical Approach*. Oxford University Press.
9. Physical Biochemistry Applications to Biochemistry and Molecular Biology – Freifelder, D. (1982). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology* (2nd ed.). W. H. Freeman.
10. Laboratory Biosafety Manual – World Health Organization (2004). *Laboratory Biosafety Manual* (3rd ed.). WHO Press.
11. Biosafety in Microbiological and Biomedical Laboratories – Centers for Disease Control and Prevention & NIH (2009). *Biosafety in Microbiological and Biomedical Laboratories* (5th ed.).
12. Pharmaceutical Engineering – Sambamurthy, K. (2006). *Pharmaceutical Engineering*. New Age International Publishers.
13. Industrial Microbiology – Prescott, S. C., & Dunn, C. G. (2004). *Industrial Microbiology*. CBS Publishers.

Mapping of course outcomes and programme outcomes
Class: M.Sc. (Sem I) Subject: Microbiology
Course: Instrumentation
Course code: MIB-501-MRM
Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	3	1	1	2	1
CO2	3	3	2	3	2	1	2	2
CO3	3	2	1	3	1	1	2	1
CO4	3	3	2	3	2	1	2	2
CO5	3	3	3	3	2	1	2	2
CO6	3	3	3	3	2	1	2	2
CO7	2	2	2	2	2	3	2	2

Justification of Mapping

PO1: Advanced Disciplinary Knowledge & Originality
Strongly mapped to all COs (especially CO1–CO6) as the course provides core knowledge of analytical techniques like chromatography, spectroscopy, electrophoresis, and centrifugation. CO7 contributes moderately as it focuses on industrial biosafety knowledge.

PO2: Research, Analysis, and Complexity
Strong mapping with CO2, CO4, CO5, and CO6 as they involve data analysis, interpretation, and experimental techniques.

Moderate relation with CO1, CO3, and CO7 where conceptual understanding supports research thinking.

PO3: Problem Solving in New Contexts
Strong in CO5 and CO6 where students apply techniques for biomolecule separation and analysis.
Moderate mapping in CO1, CO2, CO4, and CO7 as they support analytical decision-making.
Lower in CO3 as it is more theoretical.

PO4: Technical Mastery and Scientific Reasoning
Strong mapping across most COs (CO1–CO6) since the course emphasizes instrumentation, operational principles, and interpretation of scientific data.
Moderate for CO7 as it deals with biosafety systems and environmental control.

PO5: Integrated Communication
Moderate relation with CO2, CO4, CO5, CO6, and CO7 where students must interpret and communicate scientific results and safety protocols.
Lower mapping in theory-heavy COs (CO1, CO3).

PO6: Ethical, Social, and Professional Judgment
Strong mapping with CO7 due to focus on biosafety practices, laboratory ethics, and regulatory compliance.
Low relation in other COs as they are more technical and conceptual.

PO7: Autonomous and Lifelong Learning
Moderate mapping across all COs as students develop analytical skills, instrumentation handling, and independent learning abilities.
Encourages continuous skill development in modern techniques

(CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from June, 2026)

Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: I**
Course Type	**: Major Mandatory Theory**
Course Name	**: Biochemistry**
Course Code	**: MIB-502-MRM**
No. of Lectures	**: 60**
No. of Credits	**: 04**

Course Objective:

1. To understand the fundamental principles of bioorganic chemistry, including covalent and non-covalent interactions essential for biomolecular structure and function.
2. To explain the chemical reactions and mechanisms involved in biological systems, with special emphasis on enzyme-catalysed reactions.
3. To describe the chemical nature and properties of nucleic acids, including their structural components, conformations, and functional roles.
4. To analyse protein chemistry concepts, such as amino acid properties, peptide bond characteristics, and hierarchical levels of protein organization.
5. To interpret the structural and functional diversity of carbohydrates, lipids, and vitamins in biological systems.
6. To apply concepts of acid–base chemistry, buffering systems, and water properties to biological and biochemical contexts.
7. To develop analytical and problem-solving skills related to biomolecular structure, stability, estimation methods, and biochemical relevance.

Course Outcome:

CO1 : Explain covalent and non-covalent interactions and their role in stabilizing biomolecular structures.

CO2 : Describe and apply principles of enzyme catalysis, including acid–base, covalent, and metal ion catalysis, with suitable biological examples.

CO3 : Illustrate the chemistry, structure, and functional significance of nucleic acids, including DNA conformations and RNA types.

CO4 : Analyse protein structure and function using concepts such as peptide bond geometry, Ramachandran plot, and levels of protein organization.

CO5 : Classify carbohydrates and lipids based on structure and function and explain their biochemical roles in living systems.

CO6 : Describe the chemistry, physiological functions, dietary sources, and deficiency disorders of fat-soluble vitamins.

CO7 : Apply biochemical principles and standard quantitative methods for estimation and characterization of carbohydrates and lipids.

Credit No.	Topic and learning point	Teaching hour
Credit I	**Bioorganic Chemistry**	**15**
	Covalent bonds: Glycosidic bonds, peptide bonds, and phosphodiester bonds.	04
	Non-covalent interactions: Hydrogen bonding, van der Waals interactions, and ionic (electrostatic) interactions.	02
	Reactions of organic molecules: Substitution, addition, elimination, rearrangement, oxidation, reduction.	02
	Bio-organic mechanisms of enzyme-catalysed reactions: Acid–base catalysis, covalent catalysis, and metal ion catalysis	02
	Properties of water and acid–base chemistry: Structure and ionization of water; pH concept of weak acids and weak bases; Henderson–Hasselbalch equation; important biological buffer systems.	05
Credit II	**Nucleic acid chemistry**	
	Structural components of nucleic acids: Bases, nucleosides, nucleotides, and phosphodiester linkages.	03
	Polarity of nucleic acids: Presence and significance of the 5′ phosphate and 3′ hydroxyl groups.	02
	Tautomerism of nitrogenous bases and its role in specific base pairing.	02
	DNA Forms: A-DNA, B-DNA, and Z-DNA conformations	01
	DNA denaturation and reassociation: Melting temperature (Tm) and Cot curves.	04
	Structure and function of RNA molecules: tRNA, rRNA, mRNA, and	03
Credit III	**Protein Chemistry**	**15**
	Classification of amino acids based on structure and properties	02
	Buffering action of amino acids	02
	Geometry of the polypeptide chain, Resonance structures of the peptide bond, Cis–trans isomerism of the peptide bond	03
	Ramachandran plot and its significance	02
	Levels of protein organization: • Secondary structures • super-secondary structures, motifs, and domains, • Tertiary and quaternary structures of proteins, with reference to myoglobin and haemoglobin	06
Credit IV	**Carbohydrate, lipid &vitamin biochemistry**	**15**
	Carbohydrate Chemistry:	
	Structure and biological functions of carbohydrates: Monosaccharides, disaccharides, oligosaccharides, and polysaccharides, with suitable examples	02
	Asymmetric (chiral) carbon atoms in sugars	01
	Reducing and non-reducing sugars	01
	Anomeric and Epimeric forms of sugars	01
	forms of sugars	01
	derivatives: Sugar alcohols, amino sugars, sugar acids, and deoxy sugars	02
	Methods for carbohydrate estimation: Any two method	01
	Lipid Chemistry	

	Fatty acids: Saturated, unsaturated, and branched-chain fatty acids	01
	Nomenclature systems of fatty acids	01
	Structure and functions of lipids: Triglycerides, phospholipids, sphingolipids, terpenes, and steroids	02
	Methods for lipid estimation : Any two standard techniques	01
	Fat-soluble vitamins: Types A, D, E, and K	01

References:

1. Clayden, Greeves, Warren and Wothers, *Organic Chemistry*, Oxford Press
2. Jerry March, *Advanced Organic Chemistry*, John Wiley
3. Voet Donald and Voet Judith G. (1995) *Biochemistry*, 2nd Ed.. John Wiley and sons, NewYork.
4. Conn Eric, Stumpf Paul K., Bruuening George, Doi Roy H., (1987) *Outlines of Biochemistry* 5th Ed, John Wiley and Sons, New Delhi.
5. Nelson D. L. and Cox M. M. (2002) *Lehninger's Principles of Biochemistry*, Mac Millan Worth Pub. Co. New Delhi
6. Segel Irvin H. (1997). *Biochemical Calculations*. 2nd Ed. John Wiley and Sons, New York.
7. Campbell M. K.(1999)Biochemistry. 3rd edition Harcourt Brace College Publishers
8. Garrett, R. H. and Grisham, C. M. (2004) *Biochemistry.* 3rd Ed. Brooks/Cole, Publishing Company, California.
9. David J Holme, Hazel Peck (1998) *Analytical Biochemistry,* 3rd Ed., Prentice Hall, PearsonEducation Limited, Harlow England.
10. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006) *Biochemistry.* 6th Edition. Freeman, NewYork.
11. Garrett, R. H. and Grisham, C. M. (2004) *Biochemistry.* 3rd Ed. Brooks/ Cole, PublishingCompany, Californ

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc. I (Sem I) **Subject: Microbiology**

Course:Biochemistry **Course code: MIB-502-MRM**

Weightage:1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Course Outcome	**Program Outcome**							
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	2	2	3	–	–	–	–
CO2	3	3	3	3	–	–	–	2
CO3	3	2	2	3	–	–	–	–
CO4	3	3	3	3	–	–	–	–
CO5	3	2	2	2	–	–	–	–
CO6	2	2	2	2	2	3	–	–

CO7	2	3	3	3	2	–	2	3

Justification for the Mapping

PO1: Advanced Disciplinary Knowledge and Originality

CO1–CO5 demonstrate deep disciplinary understanding.

CO7 enhances applied biochemical knowledge through laboratory-based estimation techniques.

PO2: Research Analysis and Complexity

CO2, CO4, and CO7 involve analysis of enzyme mechanisms, protein structural interpretation, and quantitative biochemical methods, fostering the ability to understand complex biochemical data and research-oriented problem analysis.

PO3: Problem Solving for New Contexts

The application of biochemical principles in enzyme catalysis (CO2), protein structure–function relationships (CO4), and analytical estimations (CO7) develops students' ability to solve biochemical problems in unfamiliar and real-world contexts.

PO4: Technical Mastery and Scientific Reasoning

Strong mapping is observed through CO1–CO4 and CO7, where learners apply molecular-level reasoning, structural analysis tools (e.g., Ramachandran plot), and standard biochemical techniques, ensuring technical competence and scientific logic.

PO5: Integrated Communication

CO6 and CO7 contribute to communication skills by enabling students to interpret nutritional, biochemical, and experimental data and present results effectively in laboratory records, reports, and academic discussions.

PO6: Ethical, Social, and Professional Judgement

CO6 addresses nutritional biochemistry, vitamin deficiencies, and health implications, encouraging ethical awareness and social responsibility related to diet, health, and professional biochemical practice.

PO7: Autonomous and Lifelong Learning

CO7 supports independent learning by engaging students in hands-on quantitative biochemical analysis, promoting self-learning, skill enhancement, and readiness for advanced studies and lifelong learning.

PO8: Employability, Innovation, and Entrepreneurship

Practical exposure through CO2 and CO7 equips students with analytical and laboratory skills relevant to pharmaceutical, food, biotechnology, and clinical industries, enhancing employability and scope for innov

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. Microbiology

(w. e. from June, 2026)

Name of the Programme	**: M.Sc. Microbiology**
Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: I**
Course Type	**: Major Mandatory (Theory)**
Course Name	**: Quantitative Biology**
Course Code	**: MIB-503-MRM**
No. of Lectures	**: 30**
No. of Credits	**: 02**

Course Objective:

1. Gain a comprehensive understanding of basic statistical concepts such as probability, hypothesis testing, estimation, sampling, and study design.
2. Learn how to summarize and describe data using measures such as mean, median, mode, variance, standard deviation, and graphical representations.
3. Master inferential methods to make predictions or inferences about a population based on sample data. This includes confidence intervals, hypothesis testing, and regression analysis.
4. Develop skills to critically evaluate and interpret statistical results in the context of biological and health sciences, considering limitations and implications.
5. Effectively communicate statistical findings to non-statistical audiences through clear and concise reporting, visualization, and interpretation of results.
6. To introduce students to fundamental statistical methods and concepts used in the analysis of biological and medical data.
7. To enable students to apply statistical techniques to real- world biological research and data analysis

Course Outcome:

CO1. Students should able to demonstrate a comprehensive understanding of fundamental statistical concepts and principles applicable to biological and health sciences.

CO2. Students should able to describe and explain various methods of data collection techniques used in biostatistics.

CO3. Students should able to describe and explain various methods of study designs, and sampling techniques used in biostatistics.

CO4. Students should able to apply appropriate statistical techniques to analyze biological and health-related data sets effectively.

CO5. Students should able to interpret statistical results, drawing meaningful conclusions and insights relevant to biological and health contexts. Critical Thinking and Problem-Solving:

CO6. Students should able to critically evaluate the validity and reliability of statistical methods used in research studies within the field of biostatistics.

CO7. Students should able to effectively communicate statistical findings to diverse audiences, including non-statistical professionals, using clear and concise language, visual aids, and appropriate documentation.

No. of Credits	Topic & Learning Points	Teaching Hours
Credit I	**Introductory Biostatistics**	**(15L)**
	• Importance of statistics in Biology	1
	• Samples and Population	1
	• Types of data	1
	• Random sampling methods and sampling errors	1
	• Scales and Variables	1
	• Collection and organization of data	2
	• Tabulation	2
	• Graphical representation (Histogram, frequency polygon and ogive curves, survival curves)	3
	• Diagrammatic representation (Simple bar diagram, percentage bar diagram, multiple bar diagram, sub-divided bar diagram and pie diagram).	3
Credit II	**Descriptive Statistics** (No descriptive questions to be asked in examination; only appropriate problems should be asked in the examination.)	**(15L)**

	• Measures of central tendency – Mean (arithmetic, geometric, harmonic), median, Percentile and mode	4
	• Measures of dispersion – Mean deviation Standard deviation and Variance	4
	• Measures of skewness; Measures of kurtosis	4
	• Regression and correlation	3

Text / Reference Books:

• Goon, Gupta and Dasgupta Fundamentals of statistics, World Press, Kolkata.

• Gupta S.P. Statistical methods, Sultanchand & Sons Publisher, New Delhi.

• Irfan Ali Khan and Atiya Khanum, Fundamentals of Biostatistics. 3rd Ed. Ukaaz, Publications, Hyderabad.

• Lindgren B.W. Statistical Theory, Macmillan Publishing Co. Inc.

• Wayne Daniel (2007) Biostatistics A foundation for Analysis in the health sciences, Edition 7,

• Wiley- India edition.

• Bernard Rosner Fundamentals of Biostatistics,5th Ed. Duxbury Thomson

• Norman T.J.Bailey Statistical methods in biology, 3rd Ed. Cambridge University Press

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc. I (Sem I) **Subject: Microbiology**

Course: Quantitative Biology **Course code: MIB-503-MRM**

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	1	3	1	1	1	1
CO2	2	3	1	2	1	2	1	1
CO3	2	3	2	2	1	2	1	1
CO4	2	3	3	3	1	1	2	2
CO5	2	3	3	2	2	2	2	1
CO6	2	3	2	2	2	3	2	1

CO7	**1**	**2**	**1**	**1**	**3**	**2**	**2**	**2**

Justification for the mapping

PO1: Advanced Disciplinary Knowledge & Originality:

· Strongly mapped with **CO1** as students develop foundational and advanced statistical knowledge relevant to biological and health sciences.

· Supported by **CO4 & CO5**, where students apply and interpret statistical knowledge in discipline-specific contexts.

PO2:Research, Analysis, and Complexity:

· Strong linkage with **CO2, CO3, CO4, CO5, CO6**.

· Students engage in research methodology, sampling, data analysis, and evaluation of statistical reliability.

· Emphasizes analytical reasoning and handling complex biological datasets.

PO3: Problem Solving in New Contexts:

· Strongly mapped with **CO4 & CO5**, where students apply statistical techniques to new biological or health problems.

· Moderately linked to **CO3 & CO6** as study design selection and evaluation involve contextual decision-making.

PO4: Technical Mastery and Scientific Reasoning:

· Strong connection with **CO1 & CO4** due to statistical tool application and scientific reasoning.

· Moderate mapping with **CO2, CO3, CO5, CO6** through methodological understanding and evaluation.

PO5: Integrated Communication:

· Strongly aligned with **CO7**, as students communicate statistical findings effectively.

· Moderately related to **CO5 & CO6**, where interpretation and evaluation require clear presentation.

PO6: Ethical, Social, and Professional Judgment:

· Strong linkage with **CO6**, as evaluating validity and reliability involves ethical research practices.

· Moderate mapping with **CO2, CO3, CO5, CO7**, particularly in responsible data collection, interpretation, and reporting.

PO7: Antonomous and Lifelong Learning:

· Supported by **CO4, CO5, CO6, CO7**, where students develop independent analytical skills and critical evaluation abilities.

· Encourages continuous learning in evolving statistical and health research methods.

PO8: Employability, Innovation, and Entrepreneurship:

· Linked to **CO4 & CO7**, as statistical data analysis and communication skills enhance employability in healthcare, research, pharmaceuticals, and public health sectors.

· Encourages innovative data-driven decision-making skills applicable in industry and entrepreneurship.

(

CBCS as per NEP 2020) FOR M.Sc. I. Microbiology

(w. e. from June, 2026)

Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: I**
Course Type	**: Major Mandatory Theory**
Course Name	**: Practical Course I**
Course Code	**: MIB-504-MRM**
No. of Lectures	**: 60**
No. of Credits	**: 02**

Course Objectives

1. To introduce the principles and applications of spectroscopy in the analysis of biological molecules.
2. To develop understanding of biological synthesis of nanoparticles using microorganisms such as actinomycetes, fungi, and yeast.
3. To impart knowledge of nanoparticle characterization techniques using UV-Visible spectroscopy.
4. To provide hands-on training in separation of biomolecules using electrophoresis techniques such as Native PAGE, SDS-PAGE, and Agarose Gel Electrophoresis.
5. To familiarize students with sample preparation, gel casting, staining, and interpretation of electrophoretic banding patterns.
6. To introduce chromatographic techniques including paper chromatography, thin layer chromatography, ion exchange, and gel filtration chromatography.
7. To develop analytical and practical skills in separation, identification, and purification of biomolecules.

Course Outcomes

After successful completion of this course, students will be able to:

CO1: Explain the principles of spectroscopy and determine molar extinction coefficient of biological molecules.

CO2: Perform biological synthesis of nanoparticles using microorganisms such as actinomycetes, fungi, and yeast.

CO3: Characterize biologically synthesized nanoparticles using UV-Visible spectroscopy.

CO4: Prepare samples, cast gels, and perform electrophoresis techniques such as Native PAGE, SDS-PAGE, and Agarose Gel Electrophoresis.

CO5: Analyze and interpret protein and DNA banding patterns obtained after electrophoresis.

CO6: Apply chromatographic techniques such as paper chromatography, TLC, ion exchange, and gel filtration for separation of biomolecules.

CO7: Evaluate experimental data and apply separation and analytical techniques for biological and microbiological applications.

CONTENTS:

Sr. No.	Name of Experiment	Teaching

		Hours
1	Determination of molar extinction coefficient of a biological molecule using UV–Visible spectrophotometry	4
2	Biological synthesis of nanoparticles using microorganisms (actinomycetes/fungi/yeast)	4
3	Characterization of biologically synthesized nanoparticles using UV–Visible spectroscopy	4
	Separation of biomolecules by Native Polyacrylamide Gel Electrophoresis	
4	Preparation of samples and casting of polyacrylamide gel for Native PAGE	4
5	Separation of protein mixture by Native Polyacrylamide Gel Electrophoresis (Native PAGE)	4
6	Staining and analysis of protein banding pattern in Native PAGE	4
	Separation of biomolecules by Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis	
7	Preparation of samples and casting of polyacrylamide gel for SDS-PAGE	2
8	Separation of protein mixture by SDS-Polyacrylamide Gel Electrophoresis (SDS-PAGE)	4
9	Staining and analysis of protein banding pattern in SDS-PAGE	4
	Separation of DNA by Agarose Gel Electrophoresis	
10	Preparation of samples and casting of agarose gel for nucleic acid electrophoresis	2
11	Separation of DNA fragments by Agarose Gel Electrophoresis (AGE)	4
12	Staining and visualization of DNA banding pattern in Agarose Gel Electrophoresis	4
13	Separation of amino acids by paper chromatography	4
14	Separation of sugars by Thin Layer Chromatography (TLC)	4
	Separation of biomolecules by Ion-Exchange chromatography	
15	Preparation of ion-exchange column and equilibration of matrix	2
16	Separation of proteins using ion-exchange chromatography	4
	Separation of biomolecules by Gel filtration chromatography	
17	Preparation and packing of gel filtration column and separation of biomolecules by size-exclusion chromatography	2
	Separation of biomolecules using Gel filtration chromatography	4

References :

1. Biochemistry – Nelson, D. L., & Cox, M. M. (2017). *Lehninger Principles of Biochemistry* (7th ed.). W. H. Freeman & Company, New York.
2. Molecular Biology of the Cell – Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2015). *Molecular Biology of the Cell* (6th ed.). Garland Science.
3. Principles and Techniques of Biochemistry and Molecular Biology – Wilson, K., & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology* (7th ed.). Cambridge University Press.
4. Introduction to Protein Structure – Branden, C., & Tooze, J. (1999). *Introduction to Protein Structure* (2nd ed.). Garland Publishing.
5. Biophysical Chemistry – Cantor, C. R., & Schimmel, P. R. (1980). *Biophysical Chemistry* (Vol. I–III). W. H. Freeman.

6. Gel Electrophoresis of Proteins – Hames, B. D., & Rickwood, D. (1998). *Gel Electrophoresis of Proteins: A Practical Approach* (3rd ed.). Oxford University Press.
7. Gel Electrophoresis of Nucleic Acids – Rickwood, D., & Hames, B. D. (1990). *Gel Electrophoresis of Nucleic Acids: A Practical Approach*. Oxford University Press.
8. Chromatography Concepts and Contrasts – Miller, J. M. (2005). *Chromatography: Concepts and Contrasts* (2nd ed.). Wiley-Interscience.
9. Principles of Instrumental Analysis – Skoog, D. A., Holler, F. J., & Crouch, S. R. (2014). *Principles of Instrumental Analysis* (6th ed.). Cengage Learning.
10. Physical Biochemistry Applications to Biochemistry and Molecular Biology – Freifelder, D. (1982). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology* (2nd ed.). W. H. Freeman.

Mapping of course outcomes and programme outcomes

Class: M.Sc. (Sem I) **Subject: Microbiology**

Course: Practical course I **Course code: MIB-504-MRM**

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

Course Outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	3	1	1	2	1
CO2	3	3	2	3	2	1	2	3
CO3	3	3	2	3	2	1	2	2
CO4	3	3	2	3	2	1	2	2
CO5	3	3	3	3	2	1	2	2
CO6	3	3	3	3	2	1	2	2
CO7	3	3	3	3	3	2	3	3

Justification of Mapping

PO1: Advanced Disciplinary Knowledge & Originality

- Strongly mapped to all COs as the course delivers in-depth knowledge of analytical techniques including spectroscopy, nanoparticle synthesis, electrophoresis, and chromatography.
- CO7 also shows strong mapping due to integration of multiple techniques in microbiological applications.

PO2: Research, Analysis, and Complexity

- Strong mapping with CO2–CO7 as these involve experimental procedures, nanoparticle synthesis, electrophoresis, chromatography, and data interpretation.
- Moderate relation with CO1 as it focuses on fundamental spectroscopic principles.

PO3: Problem Solving in New Contexts

- Strong mapping with CO5, CO6, and CO7 where students analyze data and apply separation techniques to solve biological problems.
- Moderate mapping with CO1–CO4 as they build analytical and technical foundations.

PO4: Technical Mastery and Scientific Reasoning

- Strong mapping across all COs due to emphasis on instrumentation, laboratory techniques, and interpretation of scientific results.
- Includes spectroscopy, nanoparticle characterization, electrophoresis, and chromatography, ensuring technical proficiency.

PO5: Integrated Communication

- Moderate to strong mapping in CO2–CO7 as students must interpret experimental data and communicate scientific findings effectively.
- Lower mapping in CO1 as it is mainly theoretical.

PO6: Ethical, Social, and Professional Judgment

- Moderate mapping with CO7 as it involves evaluation of experimental data and application in real-world microbiological contexts, including safe laboratory practices.
- Lower mapping in other COs as they are primarily technical.

PO7: Autonomous and Lifelong Learning

- Moderate to strong mapping across all COs, especially CO7, as students develop independent experimental skills, analytical thinking, and adaptability to new techniques.
- Encourages continuous learning in advanced instrumentation and biotechnology fields.

PO8: Employability, Innovation, and Entrepreneurship

- Strong mapping with CO2 and CO7 due to biological nanoparticle synthesis and application-based learning, which have industrial and research relevance.
- Moderate mapping with CO3–CO6 as these techniques are widely used in biotechnology, pharmaceuticals, diagnostics, and research labs.

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from June, 2026)
Name of the Programme : M.Sc. Microbiology

Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: I**
Course Type	**: Major Mandatory Practical**
Course Name	**: practical course II**
Course Code	**: MIB-505-MRM**
No. of Lectures	**: 60**
No. of Credits	**: 02**

Course Objectives

1. To understand and apply Good Laboratory Practices (GLP), including safety, waste disposal, documentation, and standardization of laboratory procedures.
2. To develop skills in calibration, validation, and preparation of sops for common analytical instruments.
3. To perform quantitative biochemical estimations of carbohydrates, proteins, nucleic acids, and lipids using standard laboratory methods.
4. To apply acid–base concepts through buffer preparation and determination of pka values.
5. To acquire proficiency in computer applications for data handling, graphical representation, and statistical analysis of experimental data.
6. To interpret experimental results using appropriate statistical tools and present data scientifically.
7. To develop competence in experimental planning, method selection, troubleshooting, and interpretation of biochemical data to meet research, quality control, and industrial laboratory requirements.

Course Outcomes

CO1 : Apply **Good Laboratory Practices (GLP)** including laboratory safety, chemical handling, waste disposal, and accurate recording of experimental observations.

CO2 : Calibrate and validate common laboratory instruments such as **pH meters and spectrophotometers**, and prepare **standard operating procedures (SOPs)** for their routine use.

CO3 Estimate **reducing sugars and total carbohydrates** from natural samples using DNSA and phenol–sulphuric acid methods, and analyze the results quantitatively.

CO4 Determine **protein concentration** from natural samples using multiple analytical techniques (Lowry, Bradford, and UV spectrophotometric methods) and compare their sensitivity and accuracy.

CO5 Apply principles of **acid–base chemistry** by determining the pKa of a weak organic acid and preparing biologically relevant buffer systems.

CO6 Estimate **biomolecules such as DNA, RNA, and lipids** using standard qualitative and quantitative biochemical assays and interpret experimental outcomes.

CO7 Use **computer tools and statistical software** to organize experimental data, generate graphical representations.

Sr. No.	Name of Experiment	Teaching Hours
UNIT 1	**Good laboratory practices**	
1	Good laboratory practices: Laboratory safety, hazard from chemicals, handling of chemicals, disposal of chemicals and cultures.	4
2	Calibration and validation instruments (pH meter, spectrophotometer).	4
3	preparing/designing SOP for the instrument.	4
UNIT 2&3	**Biochemistry**	
4	Estimation of reducing sugar by DNSA method from a natural sample	4
5	Estimation of total carbohydrate by Phenol sulphuric acid method from the naturalsample	4
6	Estimation of protein from a natural sample by Lowry method	4
7	Estimation of protein from a natural sample by Bradford method	4
8	Determination of pKa of a monoprotic weak organic acid	4
9	Preparation of phosphate and acetate buffer.	4
10	Estimation of DNA by diphenyl amine method	4
11	Estimation of RNA by Orcinol Method	4
12	Qualitative tests for proteins and amino acids – Biuret, Ninhydrin, Xanthoproteic	4
13	Quantitative estimation of lipids–– Acid value / Saponification value / Iodine value (any one).	4
UNIT 4:	**Computer application and statistical analysis of data**	
14	Computer applications: Using data sheets, and sorting data with different parameters	4
15	Plotting graphs – bar charts, line graphs, pie charts, adding error bars	4

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc. I (Sem I) **Subject: Microbiology**

Course: Practical Course II **Course code: MIB-505-MRM**

Mapping of Program Outcomes with Course Outcomes

Weightage:1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	–	–	3	2	3	2	–

CO2	2	2	2	3	2	2	2	3
CO3	2	3	3	3	2	–	–	3
CO4	2	3	3	3	2	–	–	3
CO5	2	2	3	3	–	–	–	–
CO6	2	3	3	3	–	–	–	3
CO7	2	3	3	3	3	–	3	3

Justification for the Mapping

PO1: Advanced Disciplinary Knowledge and Originality

This laboratory course strengthens core biochemical knowledge through hands-on estimation of carbohydrates, proteins, nucleic acids, lipids, buffers, and acid–base systems. CO1–CO6 reinforce applied understanding of biochemical principles essential for advanced disciplinary competence.

PO2: Research Analysis and Complexity

CO2, CO3, CO4, CO6, and CO7 involve method validation, comparison of analytical techniques, interpretation of quantitative results, and statistical evaluation, thereby developing the ability to analyze complex experimental data in a research context.

PO3: Problem Solving for New Contexts

Students solve experimental and analytical problems such as selecting appropriate assays, comparing sensitivities of methods, preparing buffers, and interpreting statistical outputs, especially through CO3–CO7, enabling problem-solving in unfamiliar laboratory situations.

PO4: Technical Mastery and Scientific Reasoning

Strongly addressed across all course outcomes, particularly CO1–CO7, through laboratory safety practices, instrument calibration, SOP preparation, biochemical estimations, buffer preparation, and statistical analysis, ensuring technical proficiency and scientific reasoning.

PO5: Integrated Communication

CO1, CO2, CO3, CO4, and CO7 emphasize accurate documentation, preparation of SOPs, data presentation, graphical representation, and interpretation of results, strengthening scientific and technical communication skills.

PO6: Ethical, Social, and Professional Judgement

CO1 and CO2 focus on GLP, laboratory safety, ethical handling of chemicals, waste disposal, and responsible data recording, fostering professional conduct and ethical laboratory practices.

PO7: Autonomous and Lifelong Learning

CO1, CO2, and CO7 encourage independent laboratory work, self-learning of analytical software, and continual skill development, preparing students for lifelong learning and adaptability in scientific environments.

PO8: Employability, Innovation, and Entrepreneurship

CO2–CO7 provide industry-relevant skills such as SOP preparation, analytical techniques, instrument handling, data analysis, and statistics, directly enhancing employability in biotechnology, pharmaceutical, food, and research laborator

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. Microbiology

(w. e. from June, 2026)

Name of the Programme	**: M.Sc. Microbiology**
Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: I**
Course Type	**: Major Elective (Theory)**
Course Name	**: Microbial Taxonomy**
Course Code	**: MIB-506-MJE(A)**
No. of Lectures	**: 30**
No. of Credits	**: 02**

Course outcome:

Course Objective:

1. Understand the principles and significance of bacterial taxonomy.
2. Explore the fundamental concepts and differences between the 5-kingdom classification system and the 3-domain classification system.
3. Familiarize with Bergey's Manuals and their role in the classification and identification of prokaryotes.
4. Learn about determinative and systematic bacteriology and the phylogenetic approach to bacterial classification.
5. Students should be familiar with key theories and frameworks related to diversity, such as social identity theory, intersectionality, and multiculturalism, and be able to critically evaluate their relevance and applicability.
6. Students should understand the impact of diversity on individuals, groups, and societies, including issues related to discrimination, privilege, and social justice.
7. Students should be able to define diversity and explain its importance in various contexts, including social, cultural, and organizational.

Course Outcome:

CO1. Students will be able to explain the principles and importance of bacterial taxonomy and classification systems.

CO2. Students will understand the differences between the 5-kingdom and 3-domain classification systems and their relevance in modern taxonomy.

CO3. Students will be proficient in using Bergey's Manuals for the classification and identification of prokaryotes.

CO4. Students will be able to apply the phenetic approach to classify bacteria based on observable characteristics and the phylogenetic approach to bacterial classification using molecular techniques and polyphasic approach to bacterial taxonomy, integrating traditional and molecular methods for classification.

CO5. Students should be able to explain and critically evaluate key theories and concepts related to diversity, such as social identity theory, intersectionality, and critical race theory.

CO6. Students should be able to analyze the complexities of diversity, including how various factors such as race, gender, sexuality, class, and ability intersect and impact individuals and societies.

CO7. Students should be able to evaluate diversity issues in various contexts, such as education, healthcare, politics, and the workplace, and understand how these issues are shaped by historical, social, and cultural factors.

No. of Credits	**Topic & Learning Points**	**Teaching Hours**
Credit I	**Introduction to Bacterial Taxonomy**	**(15L)**
	• Science of classification	**2**
	• The 5-Kingdom classification system	**2**
	• The 3-Domain classification system	**2**
	• Determinative Bacteriology (Phenetic Approach)	**3**
	• Systematic Bacteriology (Phylogenetic Approach)	**3**
	• Polyphasic Approach	**3**
Credit II	**Advanced Microbial Taxonomy**	**(15L)**
	Genotypic Methods in Taxonomy	
	a. 16S rRNA gene sequence analysis	**1**
	b. 18S rRNA and ITS region analysis (for fungi)	**1**
	c. 28S rRNA gene sequence analysis	**1**
	d. Average Nucleotide Identity (ANI)	**1**
	e. Multilocus Sequence Typing (MLST)	**1**
	f. Whole Genome Sequencing (WGS) in taxonomy	**1**

	Chemotaxonomy and Protein-Based Methods	
	a. Cell wall composition	**1**
	b. Fatty Acid Methyl Ester (FAME) analysis	**2**
	c. Protein profiling	**2**
	d. MALDI-TOF MS in microbial identification	**2**
	e. Serological methods	**2**

Text / Reference Books:

1. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 8th Edition, 1974.
2. Breed and Buchanan. Bergey's Manual of Determinative Bacteriology. 9th Edition, 1982.
3. Breed and Buchanan. Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5) (2001 – 2003).
4. Sykes, G. and F. A. Skinner (Eds). Actinomycetales: Characteristics and Practical Importance. Society for Applied Bacteriology Symposium Series No. 2, Academic Press. 1973.
5. Jacquelyn G. Black (2013) Microbiology: Principles and Explorations, 6th Edition, John Wiley & Sons, Inc.,
6. Species Divergence and the measurement of microbial diversity. Catherine Lozupone and Rob Knight. FEMS Microbiol. Rev. 32 (2008) 557 – 578
7. Methods of studying soil microbial diversity. Jennifer Kirk et al, (2004). Journal of Microbiological Methods 58, 169 – 188.
8. Keller M. and Zengler K. (2004) Tapping in to Microbial Diversity. Nature Reviews 2, 141- 150.
9. Pace N. (1997) A Molecular View of Microbial Diversity and the Biosphere, Science, 276, 734- 740.
10. Woese C. (1987), Bacterial Evolution. Microbiological Reviews, 221-271.
11. Michael S. Rappe and Stephen J. Giovannoni (2003). The Uncultured Microbial Majority. Annual Review of Microbiology, 57: 369 – 94.
12. Rakesh Sharma, Ravi Ranjan, Raj Kishor Kapardar and Amit Grover (2005). 'Unculturavble' bacterial diversity: An untapped resource. Current Science, 89 (1).
13. Sonia R. Vartoukian, Richard M. Palmer and William G. Wade (2010). Strategies for culture of 'unculturable' bacteria. Minireview, FEMS Microbiol Lett 309, 1 – 7.

14. James D. Oliver (2005). The Viable but Nonculturable State in Bacteria (2005). The Journal of Microbiology, 43, Special Issue, 93 – 100.
15. Jacquelyn G. Black (2013) Microbiology: Principles and Explorations, 6th Edition, John Wiley & Sons, Inc.,
16. Microbial Diversity: Form and Function in Prokaryotes, Published Online: 30 NOV 2007. DOI: 10.1002/9780470750490.ch1
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18. Carl R. Woese. The archaeal concept and the world it lives in: a retrospective. Photosynthesis Research 80: 361 – 372, 2004. Kluver Academic Publishers.
19. Ridley Mark (2004). Evolution. Blackwell Science Ltd.

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Class: M.Sc. I (Sem I) **Subject: Microbiology**

Course: Microbial Taxonomy (Theory) **Course code: MIB-506-MJE(A)**

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	1	2	1	–	1	–
CO2	3	2	1	2	1	–	1	–
CO3	2	2	2	3	1	1	1	2
CO4	3	3	3	3	1	1	2	2
CO5	2	3	2	–	3	3	2	1
CO6	2	3	2	–	3	3	2	1
CO7	2	3	3	–	3	3	2	2

Justification for the mapping

PO1: Advanced Disciplinary Knowledge & Originality:

• Strongly mapped with CO1, CO2, CO4 (3): These COs build deep disciplinary knowledge in microbial taxonomy and classification systems.

• Moderately mapped with CO3, CO5, CO6, CO7 (2): Application of manuals and diversity theories enhances disciplinary breadth.

PO2:Research, Analysis, and Complexity:

• Strongly mapped with CO4, CO5, CO6, CO7 (3): Phylogenetic methods and diversity analysis require critical thinking and handling complex systems.

• Moderately mapped with CO1, CO2, CO3 (2): Understanding classification systems and using Bergey's Manual involves analytical reasoning.

PO3: Problem Solving in New Contexts:

• Strongly mapped with CO4, CO7 (3): Applying polyphasic approaches and evaluating diversity issues in varied contexts involves adaptive problem-solving.

• Moderately mapped with CO3, CO5, CO6 (2): Practical classification and diversity analysis require contextual application.

PO4: Technical Mastery and Scientific Reasoning:

• Strongly mapped with CO3 & CO4 (3): Use of Bergey's Manual, phenetic/phylogenetic/molecular techniques demonstrate scientific reasoning and technical competence.

• Moderately mapped with CO1 & CO2 (2): Theoretical scientific foundation.

• Not mapped with CO5–CO7: These are social theory focused.

PO5: Integrated Communication:

• **S**trongly mapped with CO1, CO2, CO4 (3): These COs build deep disciplinary knowledge in microbial taxonomy and classification systems.

• Moderately mapped with CO3, CO5, CO6, CO7 (2): Application of manuals and diversity theories enhances disciplinary breadth.

• Strongly mapped with CO5, CO6, CO7 (3): Critical discussion of diversity and social frameworks requires effective interdisciplinary communication.

• Low mapping with CO1–CO4 (1): Communication involved but not primary focus.

PO6: Ethical, Social, and Professional Judgment:

• Strongly mapped with CO5, CO6, CO7 (3): Diversity theories and evaluation of social contexts directly address ethical reasoning and social responsibility.

• Low mapping with CO3 & CO4 (1): Ethical laboratory practices and responsible scientific conduct.

• No mapping with CO1 & CO2: Primarily conceptual knowledge.

PO7: Antonomous and Lifelong Learning:

• Moderately mapped with CO4, CO5, CO6, CO7 (2): Encourages independent inquiry in taxonomy updates and evolving diversity frameworks.

• Low mapping with CO1, CO2, CO3 (1): Foundational knowledge supporting lifelong learning.

PO8: Employability, Innovation, and Entrepreneurship:

• Moderate mapping with CO3, CO4, CO7 (2): Skills in microbial identification, molecular taxonomy, and diversity evaluation enhance employability in research, healthcare, biotech, education, and policy sectors.

• Low mapping with CO5, CO6 (1): Diversity literacy improves professional readiness.

• No mapping with CO1 & CO2: Knowledge-oriented outcomes.

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. Microbiology

(w. e. from June, 2026)

Name of the Programme	**: M.Sc. Microbiology**
Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: I**
Course Type	**: Major Elective (Theory)**
Course Name	**: Bioinformatics**
Course Code	**: MIB-506-MJE(B)**
No. of Lectures	**: 30**
No. of Credits	**: 02**

Course Objective:

1. To introduce students to the fundamental concepts, scope, and historical development of Bioinformatics.
2. To provide understanding of the role of computers and computational tools in biological data analysis.
3. To explain the Central Dogma of Molecular Biology and different types of biological data (DNA, RNA, Protein).
4. To familiarize students with biological literature databases and data retrieval techniques.
5. To introduce major areas such as Genomics, Proteomics, and Systems Biology and their real-world applications.
6. To develop knowledge of biological databases, sequence alignment methods, and dynamic programming concepts.
7. To provide practical exposure to bioinformatics tools and software such as BLAST, FASTA, PDB, RASMOL, and homology modeling techniques.

Course Outcome:

CO1. Explain the concepts, scope, and historical development of Bioinformatics and its interdisciplinary nature.

CO2. Describe the Central Dogma of Molecular Biology and classify different types of biological data (DNA, RNA, Protein).

CO3. Demonstrate the ability to search, retrieve, and interpret data from biological literature databases.

CO4. Compare and analyze Genomics, Proteomics, and Systems Biology approaches and their applications in agriculture, medicine, and biotechnology.

CO5. Perform and interpret sequence alignment (local, global, pairwise, and multiple sequence alignment) using computational methods.

CO6. Apply dynamic programming principles and homology modeling techniques for 3-D protein structure prediction.

CO7. Utilize bioinformatics tools and databases (e.g., BLAST, FASTA, GenBank, PDB, OMIM, RASMOL) for biological data analysis and visualization.

No. of Credits	Topic & Learning Points	Teaching Hours
Credit I	**Introduction to Bioinformatics**	**(15L)**
	• Definition, scope and history of Bioinformatics	2
	• Role of computers in biology	1
	• Central Dogma of Molecular Biology	2
	• Types of biological data (DNA, RNA, Protein)	3
	• Literature Databases (Searching and Downloading)	2
	• Overview of Genomics, Proteomics and Systems Biology	3
	• Applications in agriculture, medicine, and biotechnology	2
Credit II	**Tools of Bioinformatics**	**(15L)**
	• General Introduction of Biological Databases	2
	• Introduction to Sequences	1
	• Sequence alignment, Local and global alignment, Pair wise sequence alignment, Multiple sequence Alignment	4
	• Dynamic Programming	1
	• Homology Modelling, 3-D protein Model	2
	• Examples of related tools (FASTA, BLAST, BLAT), databases (GENBANK, PDB, OMIM) and software (RASMOL, Ligand Explorer).	5

Text / Reference Books:

• Wilson Keith and Walker John (2005) Principles and Techniques of Biochemistry and Molecular Biology, 6th Ed. Cambridge University Press, New York.

• Pattabhi, V. and Gautham, N. (2002) Biophysics. Kluwer Academic Publishers, New York and Narosa Publishing House, Delhi.

• Lesk, A. – Introduction to Bioinformatics

• Mount, D.W. – Bioinformatics: Sequence and Genome Analysis

• Baxevanis & Ouellette – Bioinformatics: A Practical Guide

Mapping of Program Outcomes with Course Outcomes

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Class: M.Sc. I (Sem I) **Subject: Microbiology**

Course: Bioinformatics **Course code: MIB-506-MJE(B)**

	Programme Outcomes (POs)							
Course outcomes (COs)	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	**3**	**2**	**1**	**2**	**2**	**2**	**2**	**1**
CO2	**3**	**2**	**1**	**2**	**1**	**1**	**1**	**1**
CO3	**2**	**3**	**2**	**2**	**3**	**2**	**2**	**1**
CO4	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**3**
CO5	**3**	**3**	**3**	**3**	**2**	**1**	**2**	**2**
CO6	**3**	**3**	**3**	**3**	**2**	**1**	**2**	**3**
CO7	**3**	**3**	**3**	**3**	**2**	**2**	**3**	**3**

Justification for the mapping

PO1: Advanced Disciplinary Knowledge & Originality:

· Strongly mapped with **CO1, CO2, CO4, CO5, CO6, CO7**.

· Students gain deep knowledge of bioinformatics concepts, biological data analysis, genomics, proteomics, and structural biology.

· Application of sequence alignment and protein modeling reflects disciplinary expertise.

· Use of BLAST, PDB, GenBank demonstrates domain mastery.

PO2:Research, Analysis, and Complexity:

· Strong linkage with **CO3, CO4, CO5, CO6, CO7**.

· Literature database searching builds research competency.

· Comparative omics analysis develops analytical thinking.

· Dynamic programming and alignment algorithms involve handling biological complexity.

· Structural prediction requires interpretation of computational results.

PO3: Problem Solving in New Contexts:

· Strongly mapped with **CO4, CO5, CO6, CO7**.

· Students solve real biological problems using computational tools.

· Sequence alignment and modeling address novel biological queries.

· Omics approaches apply knowledge to agriculture, medicine, and biotech problems.

PO4: Technical Mastery and Scientific Reasoning:

· Strong association with **CO5, CO6, CO7**.

· Application of algorithms (Needleman-Wunsch, Smith-Waterman).

· Use of modeling and visualization tools (RASMOL, PDB).

· Scientific reasoning applied in interpreting alignment scores and structure predictions.

PO5: Integrated Communication:

· Moderately mapped with **CO3 and CO4**.

· Students interpret biological data and literature.

· Presentation of comparative omics analysis enhances scientific communication.

· Reporting alignment and modeling results improves technical documentation skills.

PO6: Ethical, Social, and Professional Judgment:

· Moderately associated with **CO1, CO3, CO4, CO7**.

· Understanding ethical handling of biological databases.

· Awareness of genomics applications in medicine and agriculture.

· Responsible use of patient data in OMIM.

· Intellectual property and bioinformatics data sharing concerns.

PO7: Antonomous and Lifelong Learning:

· Strong relation with **CO7 and CO3**.

· Students independently explore databases and tools.

· Exposure to evolving computational biology tools fosters lifelong learning.

· Self-directed research using literature databases.

PO8: Employability, Innovation, and Entrepreneurship:

· Strong mapping with **CO4, CO6, CO7**.

· Skills in genomics, proteomics, modeling highly relevant to biotech and pharma industries.

· Use of real-world tools enhances employability.

· Exposure to computational approaches promotes innovation in research and startups.

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. Microbiology

(w. e. from June, 2026)

Name of the Programme	**: M.Sc. Microbiology**
Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: I**
Course Type	**Major Elective**
Course Name	**: Practical Course III (A)**
Course Code	**: MIB-507-MJE(A)**
No. of Lectures	**: 60**
No. of Credits	**: 02**

Course Objective:

1. To Gain practical experience in handling natural samples and isolating specific types of bacteria and interpret the characteristics of Actinomycetes bacteria.
2. To Explore methods for the isolation and identification of mold and yeast from natural samples, the morphological and biochemical characteristics of mold and yeast and document the findings from the isolation and identification process.
3. To understand the ecological importance of Cyanobacteria & the morphological and physiological characteristics of Cyanobacteria.
4. To explore the diversity of extremophiles bacteria through the isolation of Thermophiles, Halophiles, Acidophiles, and Alkaliphiles types & the unique adaptations of extremophiles bacteria to extreme environmental conditions.
5. Understand adaptations of extremophiles to extreme environments and relate them to their ecological roles.
6. Apply physiological and biochemical tests for characterization of extremophiles under specific environmental conditions (temperature, pH, salinity).
7. Record and interpret experimental observations systematically using laboratory notebooks and microbial identification keys.

Course Outcome:

CO1. Learn to characterize the microbial system for the production of various primary and secondary metabolites having potential biotechnological application

CO2. Gain the knowledge of biosafety rules to be followed while handling the environmental samples

CO3. To Gain practical experience in handling natural samples and isolating specific types of bacteria and interpret the characteristics of Actinomycetes bacteria.

CO4. Students will master the isolation techniques for extremophiles bacteria, including Thermophiles, Halophiles, Acidophiles, and Alkaliphiles types, illustrating proficiency in handling microorganisms thriving in extreme conditions

CO5. The sampling techniques for isolation of fungi.

CO6. Students will be able to isolate actinomycetes bacteria from natural samples, demonstrating proficiency in bacterial isolation techniques and understanding their characteristics.

CO7. Students will acquire skills in the isolation and identification of mold and Yeast from natural samples, showcasing competence in fungal identification techniques and knowledge of their characteristics.

No of Experiments	Topic	Teaching Hours
Unit 1	**Isolation of Actinomycetes, fungi and cyanobacteria**	
1-2	Isolation & characterisation of Actinomycetes from natural sample.	8
3-6	Isolation and characterisation of the following types of fungi from natural sample. (Identification by classical methods: Slide culture plate technique, Lactophenol cotton blue staining- Mycelium and spore morphology) a. Mold. b. Yeast.	16
7	Isolation and observation of Cyanobacteria from natural sample.	4
Unit 2	**Isolation of extremophiles**	
8-11	Isolation and characterisation of the following types of extremophiles from natural sample. A. Thermophiles B. Halophiles	16
Unit 3	**Molecular Phylogenetics and rRNA-Based Sequence Analysis**	

12	16SrRNA gene sequence analysis by using BLAST algorithm	4
13	18SrRNA gene sequence analysis by using BLAST algorithm.	4
14	ITS gene sequence analysis by using BLAST algorithm.	4
15	Phylogenetic analysis and tree building methods by using FASTA	4

Text / Reference Books:

•Bisen, P.S. (2014). Laboratory Protocols in Applied Life Sciences (1st ed.). CRC Press.

•Horikhoshi and Grant. Extremophiles- Microbial life in Extreme Environment

•Parkinson, d., and S. T. Williams. "a method for isolating fungi from soil microhabitats." plant and soil, vol. 13, no. 4, 1961, pp. 347–55. jstor

• WARCUP, J. The Soil-Plate Method for Isolation of Fungi from Soil. Nature 166, 117–118 (1950).

Mapping of Program Outcomes with Course Outcomes

Class: M.Sc. I (Sem I) **Subject: Microbiology**

Course: Practical Course III(A) **Course code: MIB-507-MJE(A)**

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relationn

	Programme Outcomes (POs)							
Course outcomes (COs)	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**3**
CO2	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**2**
CO3	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**3**
CO4	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**3**
CO5	**3**	**3**	**2**	**3**	**2**	**2**	**2**	**3**
CO6	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**3**
CO7	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**3**

Justification for the mapping

PO1: Advanced Disciplinary Knowledge & Originality:

· CO1 develops advanced understanding of microbial metabolite production and biotechnology applications.

· CO3, CO4, CO6, and CO7 strengthen in-depth knowledge of bacterial and fungal diversity.

· CO5 enhances mycological knowledge.

· CO2 contributes moderately by introducing biosafety principles linked to microbiology.

PO2:Research, Analysis, and Complexity:

· CO1 involves analytical evaluation of metabolite production systems.

· CO3, CO4, CO6, and CO7 require experimental isolation, observation, and interpretation of microbial characteristics.

· CO5 includes analytical sampling techniques for fungi.

· CO2 moderately supports risk assessment and laboratory analysis.

PO3: Problem Solving in New Contexts:

· CO3 and CO6 require solving challenges in selective isolation of actinomycetes.

· CO4 demands adaptation of techniques to extreme environmental conditions.

· CO1 applies microbial systems for industrial/biotech problem solving.

· CO5 moderately applies sampling strategies in diverse ecosystems.

· CO2 supports problem-solving in laboratory safety scenarios.

PO4: Technical Mastery and Scientific Reasoning:

· CO3, CO4, CO6, and CO7 require mastery in culturing, isolation, and identification techniques.

· CO1 develops scientific reasoning in metabolite production systems.

· CO5 strengthens technical skills in fungal isolation.

· CO2 provides disciplined laboratory practice through biosafety.

PO5: Integrated Communication:

· CO7 has high mapping (3) as fungal identification requires documentation and presentation of findings.

· CO1, CO3, CO4, CO5, and CO6 involve recording, interpreting, and reporting experimental results.

· CO2 requires communication of biosafety protocols.

PO6: Ethical, Social, and Professional Judgment:

· CO2 which directly addresses biosafety, ethical laboratory handling, and environmental responsibility.

CO1, CO3, CO4, CO5, CO6, and CO7 moderately support professional conduct in microbial handling.

PO7: Antonomous and Lifelong Learning:

· CO2 encourages continuous adherence to evolving biosafety standards.

· CO3, CO4, CO6, and CO7 promote independent laboratory skill development.

· CO1 encourages exploration of emerging microbial biotechnology applications.

PO8: Employability, Innovation, and Entrepreneurship:

· CO1 links directly to industrial microbiology, fermentation, and biotechnology sectors.

· CO3 and CO6 are relevant to pharmaceutical and antibiotic industries.

· CO4 supports industrial enzyme and extremophile applications.

· CO5 and CO7 apply to food, agriculture, and clinical microbiology industries.

· CO2 ensures industry-ready laboratory safety compliance

SYLLABUS (CBCS as per NEP 2020) FOR M.Sc. Microbiology

(w. e. from June, 2026)

Name of the Programme	**: M.Sc. Microbiology**
Program Code	**: PSMI**
Class	**: M.Sc. I**
Semester	**: I**
Course Type	**Major Elective**
Course Name	**: Practical Course IV (B)**
Course Code	**: MIB-507-MJE (B)**
No. of Lectures	**: 60**
No. of Credits	**: 02**

Course Objective:

1. Understand the principles of sequence similarity searching using the BLAST algorithm for biological data analysis.
2. Perform genome sequence analysis using nucleotide databases such as BLASTn to identify homologous DNA sequences.
3. Conduct protein sequence analysis using BLASTp to detect conserved regions and functional similarities.
4. Apply iterative sequence searching techniques using PSI-BLAST for identifying distant homologs and performing multiple sequence alignment.
5. Translate nucleotide sequences into amino acid sequences and identify potential protein-coding regions using BLASTx
6. Perform phylogenetic analysis and construct evolutionary trees using sequence alignment tools such as FASTA.
7. Analyze and visualize three-dimensional protein structures from the Protein Data Bank using the iCn3D structure viewer.

Course Outcome:

CO1. Execute BLAST searches independently and interpret E-values, scores, and alignment statistics for genomic and proteomic data.

CO2. Identify homologous DNA sequences and annotate genomic regions using nucleotide BLAST tools.

CO3. Analyze protein sequences to determine conserved domains, functional motifs, and evolutionary relationships.

CO4. Perform multiple sequence alignments and detect distant evolutionary relationships using PSI-BLAST.

CO5. Predict protein-coding genes from nucleotide sequences through translation and BLASTx analysis.

CO6. Construct and interpret phylogenetic trees to understand evolutionary divergence among species or genes.

CO7. Retrieve, visualize, and interpret protein 3D structures from PDB and analyze structural features such as active sites, secondary structures, and ligand interactions using iCn3D.

No of Experiments	Topic	Teaching Hours
1-2	Sequence analysis by using BLAST algorithm. a. Genome sequence analysis by using BLAST algorithm. b. Protein sequence analysis by using BLAST algorithm.	8
3	Multiple Sequence Alignment by using PSI- BLAST	4
4	DNA translation from nucleotides to amino acids and identifying potential protein products encoded by a nucleotide using blastx.	4
5	Phylogenetic analysis and tree building methods by using FASTA.	4
6	Determination of protein structure (PDB) by using iCn3D structure viewer.	4
7	Gene Prediction and Annotation (Prokaryotic & Eukaryotic) Tools: GeneMark, AUGUSTUS, ORF Finder	4
8	Motif Discovery and Functional Domain Analysis Tools: MEME Suite, InterProScan, Pfam	4
9	Promoter Prediction and Regulatory Element Analysis Tools: Promoter 2.0, Neural Network Promoter Prediction	4
10	RNA Secondary Structure Prediction Tools: RNAfold (ViennaRNA), Mfold	4
11	Molecular Docking Analysis Tools: AutoDock, PyRx	4
12	SNP Detection and Variant Analysis Tools: Ensembl Variant Effect Predictor (VEP), dbSNP	4

13	Homology Modeling of Proteins Tools: SWISS-MODEL, Phyre2	4
14	Metagenomic Data Analysis Tools: QIIME, MG-RAST	4
15	Gene Expression Analysis (Microarray / RNA-Seq Data) Tools: GEO database, DESeq2 (R)	4

References:

1. Wang, J., et al. (2020).iCn3D: from web-based 3D viewer to structural analysis tool in batch mode.Nucleic Acids Research, 48(W1), W364–W370.
2. NCBI iCn3D official page
3. Altschul, S. F., et al. (1990).Basic Local Alignment Search Tool.Journal of Molecular Biology, 215(3), 403–410.
4. Altschul, S. F., et al. (1997). Gapped BLAST and PSI-BLAST: a new generation of protein database search programs. Nucleic Acids Research, 25(17), 3389–3402.
5. NCBI BLAST DocumentationNational Center for Biotechnology Information (NCBI). https://blast.ncbi.nlm.nih.gov
6. Mount, D. W. (2004)*Bioinformatics: Sequence and Genome Analysis.* Cold Spring Harbor Laboratory Press. Detailed explanation of BLAST statistics and genome searches.
7. Baxevanis, A. D., & Ouellette, B. F. F. (2005).*Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins.* Wiley. Practical examples of BLAST for DNA and protein.

Mapping of course outcomes and programme outcomes:

Class: M.Sc. I **Subject: Microbiology**

Course: Practical Course IV(B) **Course code: MIB-507-MJE(B)**

Weightage: 1= weak or low relation, 2= Moderate or partial relation, 3= Strong or direct relation

	Programme Outcomes (POs)							
Course outcomes (COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	**3**	**3**	**2**	**3**	**2**	**1**	**2**	**2**
CO2	**3**	**3**	**2**	**3**	**2**	**1**	**2**	**2**
CO3	**3**	**3**	**3**	**3**	**2**	**1**	**2**	**3**
CO4	**3**	**3**	**3**	**3**	**2**	**1**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**2**	**1**	**2**	**3**
CO6	**3**	**3**	**3**	**3**	**2**	**1**	**3**	**3**
CO7	**3**	**3**	**2**	**3**	**2**	**1**	**2**	**3**

Justification for the mapping

PO1: Advanced Disciplinary Knowledge & Originality:

CO1:Demonstrates advanced disciplinary knowledge in genomics and proteomics.

CO2:Strengthens core genomic annotation knowledge.

CO3: Deepens protein functional and evolutionary knowledge.

CO4:Provides advanced understanding of sequence evolution.

CO5:Strengthens gene prediction knowledge.

CO6:Advanced evolutionary biology knowledge.

CO7:Advanced structural bioinformatics knowledge.

PO2:Research, Analysis, and Complexity:

CO1:Involves analytical interpretation of E-values, scores, and statistical significance.

CO2:Requires research-oriented analysis of sequence similarity.

CO3:Interpretation of conserved domains and motifs.

CO4:Involves comparative research analysis.

CO5:Analytical interpretation of translated products.

CO6: Research-level interpretation of divergence patterns.

CO7:Analytical interpretation of structural features.

PO3: Problem Solving in New Contexts:

CO1:Applies BLAST to new biological problems.

CO2: Applies homology search to unfamiliar datasets.

CO3:Solves biological function prediction problems.

CO4:Detects distant homology in new datasets.

CO5:Problem-solving in unknown genomic contexts.

CO6:Solves evolutionary relationship problems

CO7:Applies structure analysis to biological problems.

PO4: Technical Mastery and Scientific Reasoning:

CO1:Requires technical mastery of computational tools.

CO2:Technical proficiency in nucleotide BLAST tools.

CO3:Technical competence in domain analysis tools.

CO4:Mastery of PSI-BLAST and alignment algorithms.

CO5:Technical expertise in sequence translation tools.

CO6:Technical mastery of tree-building methods.

CO7:Technical competence in visualization tools.

PO5: Integrated Communication:

CO1:Interpretation and reporting of alignment results.

CO2:Presentation of annotation findings.

CO3:Communication of functional interpretations.

CO4:Reporting phylogenetic insights.

CO5:Explaining predicted protein products.

CO6: Presentation and interpretation of trees.

CO7:Communication of structural insights.

PO6: Ethical, Social, and Professional Judgment:

CO1:Minimal ethical involvement (data usage awareness).

CO2:Limited ethical implications.

CO3:Minimal ethical considerations.

CO4:Limited ethical component.

CO5:Limited ethical issues.

CO6:Minimal ethical involvement.

CO7:Ethical awareness in structural data usage.

PO7: Antonomous and Lifelong Learning:

CO1:Encourages independent tool usage.

CO2:Promotes independent exploration of databases.

CO3:Encourages continuous database exploration.

CO4:Promotes autonomous research skill development.

CO5:Encourages self-driven genome exploration.

CO6:Encourages independent evolutionary analysis.

CO7:Encourages continued skill enhancement.

PO8: Employability, Innovation, and Entrepreneurship:

CO1:Foundational employability skill in biotech and research labs.

CO2:Important for genomics and industry positions.

CO3:Highly relevant to drug design and biotech innovation.

CO4:Core competency in evolutionary bioinformatics.

CO5: Valuable in genome annotation industries.

CO6:Relevant in evolutionary genomics and biodiversity research.

CO7:Highly relevant in pharmaceutical and biotech sectors

(CBCS as per NEP 2020) FOR M.Sc. I. Microbiology
(w. e. from June, 2026)

Name of the Programme : M.Sc. Microbiology
Program Code : PSMI
Class : M.Sc. I
Semester : I
Course Type : Research Methodology
Course Name : Research Methodology
Course Code : MIB-508-RM
No. of Lectures : 60
No. of Credits : 04

Course Objectives:

1. To understand the historical development and fundamental concepts of scientific research.
2. To familiarize students with various types of research and emerging research trends.
3. To develop the ability to identify, define and formulate research problems and objectives.
4. To understand different research designs and their applications in microbiological research.
5. To apply appropriate research methods, sampling techniques and data analysis procedures.
6. To develop skills in scientific communication including literature review, citation, report writing and presentation.
7. To understand research ethics, intellectual integrity, responsible use of AI, and preparation of research proposals.

Course Outcomes:

CO. 1 Explain the evolution, concepts and various types of research in scientific investigations.
CO. 2 Identify and formulate research problems and construct clear research objectives.
CO. 3 Select and apply appropriate research designs for experimental and analytical studies.
CO. 4 Apply quantitative, qualitative and mixed research methods including appropriate sampling techniques.
CO. 5 Analyze and interpret research data using basic statistical concepts and present findings logically.
CO. 6 Demonstrate competency in scientific writing, citation practices, literature review formal presentation skills.
CO. 7 Adhere to research ethics, plagiarism policies and responsibly use AI tools while preparing research proposals.

Credit	Topic / Learning Points	Lectures
I	**Foundations of Research**	**15**
	History of Research	3
	Research concept: Definition, characteristics, objectives, utility	3

	Types of research (Descriptive vs Analytical, Applied vs Fundamental, Quantitative vs Qualitative, Conceptual vs Empirical)	5
	Current trends in research (Mono-disciplinary, Interdisciplinary, Transdisciplinary, threats and challenges to good research)	4
II	**Research Problem & Design**	**15**
	Origin of research problem	2
	Defining the research problem	2
	Formulating the research problem	2
	Research objectives	2
	Descriptive research design	2
	Correlational research design	2
	Experimental research design	3
III	**Research Methods & Data Handling**	**15**
	Quantitative research	2
	Qualitative research	2
	Experimental research	2
	Mixed methods approach	2
	Sample collection and processing techniques (Water, Soil, Air, Medical samples)	4
	Data analysis and interpretation	3
IV	**Scientific Communication, Ethics & Proposal Writing**	**15**
	Literature review (purpose, types of information, primary & secondary sources)	3
	Citation methods & bibliography	2
	Research report writing (types, formats, components of research paper)	3
	Data presentation (PowerPoint, scientific poster, presentation skills)	3
	Ethical issues, copyrights & plagiarism	2
	Ethical use of AI in scientific writing	1
	Preparation of project proposal (time frame, work plan, budget justification)	1

References:

1. Research in Medical and Biological Sciences: From Planning and Preparation to Grant Application and Publication. (2015). Netherlands: Elsevier Science.
2. Arora, R. (2004). Encyclopedia of Research Methodology in Biological Sciences. India: Anmol Publications Pvt. Limited.
3. Handbook of Research Methodology: A Compendium for Scholars & Researchers. (2017). Educreation Publishing.
4. Kumar, R. (2010). Research Methodology: A Step-by-Step Guide for Beginners. United Kingdom: SAGE Publications.

Mapping of Program Outcomes with Course Outcomes

Course: Research Methodolgy Course code: MIB-508-RM

Weightage:1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

	Programme Outcomes (POs)							
Course Outcomes	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**
CO 1	3	2	1	1	1	1	1	1
CO 2	2	3	2	1	1	1	2	1
CO 3	2	3	3	2	1	1	2	1
CO 4	2	3	2	3	1	1	1	2
CO 5	2	3	2	2	3	1	1	2
CO 6	2	2	1	1	3	2	2	1
CO 7	1	2	1	1	2	3	2	1

Justification for the mapping

PO1 – Advanced Disciplinary Knowledge
Strongly supported by CO1, CO2, CO3 (research concepts and design).

PO2 – Research, Analysis & Complexity
Highly aligned with CO2, CO3, CO4, CO5 (research design, data analysis).

PO3 – Problem Solving in New Contexts
Addressed through CO2, CO3, CO4 (problem formulation & application).

PO4 – Technical Mastery & Scientific Reasoning
Strong in CO3 and CO4 (method selection & technical tools).

PO5 – Integrated Communication
Strongly mapped with CO5 & CO6 (data presentation & scientific writing).

PO6 – Ethical, Social & Professional Judgment
Strongly aligned with CO7 (ethics, plagiarism, AI responsibility).

PO7 – Autonomous & Lifelong Learning
Moderately supported via CO2, CO6, CO7.

PO8 – Employability, Innovation & Entrepreneurship
Moderately supported via CO4 & CO5 (research skills & analytical competency).