Ordinance No. :- V-141-B-10

(Approved in Academic Council meeting held on 11.03.2026
Proposed to be ratified in forthcoming executive council)

Evaluation Scheme and Syllabus

of

M.Sc. MICROBIOLOGY

TWO – YEAR POST GRADUATE

PROGRAM

(AS PER NEP-2020)

Keral Verma Subharti College of Science

Swami Vivekanand

SUBHARTI UNIVERSITY

Meerut

(Effective from session 2025-26)

K. V. Subharti College of Science
S V Subharti University
NH-58 Bypass Road, Meerut

Programme Objectives

The M.Sc. Microbiology programme aims to provide advanced theoretical knowledge and hands-on expertise in microbiology, emphasizing microbial diversity, molecular mechanisms, genetic manipulation, host–microbe interactions, biotechnology, and industrial applications. The programme is designed to prepare students for research, academia, healthcare, diagnostics, bioprocess industries, and emerging areas such as genomics, nanotechnology, and computational biology.

Programme Objectives

1. **Advanced Understanding of Microorganisms:**
   To provide in-depth knowledge of microbial diversity, cellular organization, genetics, genomics, proteomics, and metabolic regulation in microbes.
2. **Laboratory and Research Skills:**
   To train students in advanced microbiological, molecular, biochemical, and biotechnological techniques used to analyze, characterize, and manipulate microorganisms.
3. **Application-Oriented Learning:**
   To offer specialized understanding of microbial toxicology, plant biotechnology, industrial microbiology, nano-microbiology, and microbial diagnostics.
4. **Data-Driven and Computational Skills:**
   To integrate knowledge of biostatistics, bioinformatics, gene sequencing, and computational approaches for analyzing microbial data.
5. **Career and Research Preparedness:**
   To prepare graduates for research projects, dissertation work, scientific communication, and future placement in academia, industry, healthcare, or entrepreneurship.

Programme Outcomes (POs) – M.Sc. Microbiology

Upon successful completion of the programme, students will be able to:

PO1 –
Demonstrate advanced understanding of microbial diversity, molecular biology, microbial physiology, biochemistry, toxicology, genomics, and proteomics.

PO2 – Design, perform, analyze, and interpret complex microbiological experiments, applying principles of molecular biology, genetic engineering, and biostatistics.

PO3 – Operate advanced laboratory instruments (PCR, gel documentation, HPLC, spectrophotometers, fermenters, bioinformatics tools, sequencing databases) with efficiency and accuracy.

PO4 – Apply cutting-edge technologies such as CRISPR, recombinant DNA techniques, omics platforms, nano-microbiology tools, and microbial biotechnology in solving real-world problems.

PO5 – Demonstrate understanding of industrial microbiology, fermentation technology, microbial product development, and diagnostic microbiology used in healthcare and biotechnology industries.

PO6 – Analyze genomic and proteomic datasets using computational tools, develop proficiency in sequence analysis, phylogenetics, and computational modeling of microbial systems.

PO7 – Follow laboratory biosafety guidelines, ethical norms, environmental responsibility, and regulatory frameworks (GLP, GMP, biosafety levels).

CREDIT DISTRIBUTION TABLE

SWAMI VIVEKANAD SUBHARTI UNIVERSITY MEERUT							
KERAL VERMA SUBHARTI COLLEGE OF SCIENCE							
Department of Biotechnology							
M.Sc. Biochemistry (Session 2025-26 onwards)							
		I	**II**	**Internship after II Sem**	**III**	**IV**	**Total**
1	Core Course	16	16	**4**	8	4	44
2	Elective (DEC)	-	-		8	8	16
3	PC/Dissertation/Project Work	8	8		8	12	36
4	Seminar/VAC/OEC/EEC/CHM	2 (Seminar)	2 (CHM)		2 (OEC)	2 (EEC)	8
	Total	26	26		26	26	108

K. V. Subharti College of Science
S. V. Subharti University
NH-58 Bypass Road, Meerut

I YEAR

SEM:I							
Batch:2025 -26				**SEM:I**			
S.*No*.	**Course Type**	**Course Code**	**Course Name**	**Teaching Load**			**Credits**
				L	**T**	**P**	
THEORY and PRACTICAL SUBJECTS							
1	Core Course 1	MSMB-101	MICROBIAL DIVERSITY AND MICROBIAL CELL BIOLOGY	4	0	0	4
2	Core Course 2	MSMB-102	Microbial Genetics and Molecular Biology	4	0	0	4
3	Core Course 3	MSMB-103	Biochemistry and Biophysics of microbes	4	0	0	4
4	Core Course 4	MSMB-104	MICROBIAL GROWTH, PHYSIOLOGY AND METABOLISM	4	0	0	4
5	Practical I (Based on CC 1 & 3)	MSMB 105P	Practical based on MSMB-101&102	0	0	4	4
6	Practical II (Based on CC 2& 4)	MSMB-106P	Practical based on MSMB-103 and 104	0	0	4	4
7	Seminar I	MSMB-107S		0	0	2	2
TOTAL CREDITS / ASSESSMENT							**26**

SEM:II							
Batch:2025-26							SEM:II
S.No.	Course Type	Course Code	Course Name	Teaching Load			Credits
				L	T	P	
THEORY and PRACTICAL SUBJECTS							
1	Core Course 5	MSMB-201	MICROBIAL TOXICOLOGY	4	0	0	4
2	Core Course 6	MSMB-202	Genomics and Proteomics	4	0	0	4
3	Core Course 7	MSMB-203	Genetic Engineering in Microbes	4	0	0	4
4	Core Course 8	MSMB-204	Biostatistics and Bioinformatics	4	0	0	4
5	Practical III (Based on CC 5 & 6)	MSMB-205P	Practical based on MSMB-201&202	0	0	4	4
6	Practical IV (Based on CC 7 & 8)	MSMB-206P	Practical based on MSMB-203&204	0	0	4	4
7	CHM 1	MSMB-207		2	0	0	2
TOTAL CREDITS / ASSESSMENT							26

First year;Semester-I

CorepaperI Subject Code: MSMB-101
Title of the paper: MICROBIAL DIVERSITY AND MICROBIAL CELL BIOLOGY
Theory (4 Credit)

Subject	**MICROBIAL DIVERSITY AND MICROBIAL CELL BIOLOGY**
Cos	**CO1: Explain microbial classification, diversity, and evolutionary relationships. CO2: Describe structure–function relationships of microbial cell components. CO3: Compare cellular organization of bacteria, archaea, fungi, algae, and protozoa. CO4: Apply microscopy and cultivation principles to study microbial diversity.**
Unit 1	**Total Hours 08** History and mile stones in microbiology. Contributions of Anton von Leeuwenhoek, Edward Jenner, Louis Pasteur, Robert Koch, Ivanowsky. Importance and applications of microbiology. Classification of microorganisms. Whittaker's five kingdom concept, Bergey's Manual of Systematic Bacteriology. General characteristics and outline classification of Bacteria, Archaea, Mycoplasmas, Cyanobacteria, Fungi, Algae, Protozoa and viruses.
Unit 2	**TotalHours:04** Methods of sterilization: Physical methods – Dry heat, moist heat, radiation methods, filtration methods, Chemical methods and their application. Microbial cultures: Concept of pure culture, Methods of pure culture isolation, Enrichment culturing techniques, single cell isolation, and pure culture development. Preservation of microbial cultures: subculturing, overlaying cultures with mineral oils, lyophilization, and cultures, storage at low temperature.
Unit 3	**TotalHours**: **12** Staining Techniques - Simple and Differential staining techniques. No. of hours: 8 Principles of microscopy - Bright field and Electron microscopy (SEM and TEM). Nutritional types of bacteria. Microbiological media-Natural and synthetic basal, defined, complex, enrichment, selective, differential, maintenance and transport media.
Unit 4	**Total Hours: 8** Microbial growth: Principles of growth, Kinetics of growth, Methods of measuring growth: Direct methods: viable plate counts, membrane filtration. Indirect methods: Metabolic activity – measurements of DNA, Protein, Microscopic counts, electronic counters, most probable number; Batch and continuous growth, Synchronous culture, Diauxic growth, Types of cultures-stock, batch, continuous and synchronous cultures. Cultivation of aerobes and anaerobes. Reproduction in bacteria and spore formation.
Unit 5	**Total Hours:08** Ultra structure of Prokaryotic cell- Variant components and invariant components. Cell wall of bacteria and fungi, Gram positive cell wall, Gram negative cell wall, Cell wall of fungi and yeasts. Morphology,Ultrastructure and chemical composition of bacteria, Actinomycetes, Spirochetes, Rickettsiae, Mycoplasma, Chlamydiae. Economic importance of algae and fungi. SCP.

Firstyear;Semester- I
Corepaper: 2 Subject Code: MSMB-102
Title of the paper: Microbial Genetics and Molecular Biology
Theory (4 Credit)

Subject	**Microbial Genetics and Molecular Biology**
	CO1: Explain molecular mechanisms of DNA replication, transcription, and translation. **CO2:** Interpret microbial genetic regulation, mutations, and gene transfer mechanisms. **CO3:** Apply principles of molecular biology tools in microbial genome study. **CO4:** Analyze genetic mapping, recombination, and operon-based regulatory systems.
Unit 1	**Total Hours 08** DNA and RNA as genetic material. Structure and organization of prokaryotic DNA. Watson and Crick model of DNA. Extra chromosomal genetic elements - Plasmids and transposons. Replication of DNA - Semi conservative mechanism, Enzymes involved in replication.
Unit 2	**TotalHours:04** Mutations - spontaneous and induced, base pair changes, frame shifts, deletions, inversions, tandem duplications, insertions. Mutagens - Physical and Chemical mutagens. Outlines of DNA damage and repair mechanisms. Genetic recombination in bacteria - Conjugation, Transformation and Transduction.
Unit 3	**TotalHours**: **12** Concept of gene Muton, Recon and Cistron. One gene one enzyme and one gene one polypeptide hypotheses. Types of RNA and their functions. Genetic code. Structure of ribosomes. Bacterial recombination – Bacterial transformation, Bacterial conjugation, Transduction Generalized and specialized transductions.
Unit 4	**Total Hours: 8** Types of genes - structural, constitutive, regulatory, clustered genes and the control of gene expression. Regulation of gene expression in bacteria - operon concepts - Negative and positive control of the Lac Operon, trp operon. Poly and Mono cistronic m-RNA.
Unit 5	**Total Hours:08** Transcription: Enzymatic Synthesis of RNA - Basic features of RNA synthesis, E.coli RNA polymerase, Classes of RNA molecules, processing of tRNA and rRNA in E.coli, Transcription in Eukaryotes, Eukaryotic rRNA genes, formation of eukaryotic tRNA molecules, RNA Polymerases of eukaryotes. Translation: Outline of Translation, The Genetic Code, The Decoding System, Codon Anticodon interaction. Protein Synthesis, Complex Translation units, Inhibitors and Modifiers of protein synthesis, Protein Synthesis in Eukaryotes.

Firstyear;Semester- I
Corepaper: 3 Subject Code: MSMB-103
Title of the paper: Biochemistry and Biophysics of microbes
Theory (4 Credit)

Subject	**Biochemistry and Biophysics of microbes**
	CO1: Explain structure and functions of biomolecules in microbes. **CO2: Describe enzyme kinetics, bioenergetics, and metabolic thermodynamics.** **CO3: Analyze biophysical principles governing microbial systems.** **CO4: Interpret biochemical pathways and their regulation in microbes.**
Unit 1	**Total Hours 08** Carbohydrates and glycobiology Monosaccharides - structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives, oxidation of sugars. Formation of disaccharides, reducing and non- reducing disaccharides.
Unit 2	**TotalHours:04** Polysaccharides – homo- and heteropolysaccharides, structural and storage polysaccharides. Structure and role of proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides). (definition, structure, functions, examples only) Carbohydrates as informational molecules, working with carbohydrates (applications of carbohydrate)
Unit 3	**TotalHours**: **12** Introduction to amino acids, peptides and proteins Amino acids: Definition, classification & structures. Physico-chemical properties of amino acids(amphoteric molecules, ionisation, zwitterions, pk values, isoelectric point, Lambert-Beer's law, optical density, absorption spectra), titration of amino acids (glycine, glutamic acid, lysine, histidine), reaction due to carboxylic acid group (reaction with base, alcohol, LiAlH4, metal oxide), separation and analysis of amino acids by paper & thin layer chromatography and HPLC.
Unit 4	**Total Hours: 8** Three dimensional structures of proteins Nature of stabilizing bonds - covalent and non-covalent. Importance of primary structure in folding. The peptide bond - bond lengths and configuration.
Unit 5	**Total Hours:08** **Thermodynamics and Bioenergetics in Microbial Systems** First and second laws of thermodynamics, Free energy changes in microbial metabolism ATP production and energy coupling mechanisms,**Transport Phenomena in Microbes** Diffusion, osmosis, and facilitated diffusion, Active transport and ion gradients, Biophysical models of membrane transport

Firstyear;Semester- I
Corepaper: 4 Subject Code: MSMB-104
Title of the paper: Microbial Growth, Physiology, and Metabolism"
Theory (4 Credit)

Subject	**Microbial Growth, Physiology, and Metabolism"**
	CO1: Explain factors influencing microbial growth and physiological responses. **CO2:** Analyze metabolic pathways in energy production and nutrient assimilation. **CO3:** Evaluate stress adaptation and survival strategies of microbes. **CO4:** Apply growth models and parameters to study microbial metabolism.
Unit 1	**Total Hours 08** **Microbial Growth** **Growth Curve and Kinetics,** Batch culture: lag, log, stationary, and death phases, Growth rate and generation time, Synchronous and continuous culture (chemostat, turbidostat) **Measurement of Growth,** Direct and indirect methods (cell count, turbidity, dry weight, ATP measurement)
Unit 2	**TotalHours:04** **Microbial Nutrition and Physiology- Nutritional Types :**Autotrophs vs. heterotrophs, Phototrophs and chemotrophs (lithotrophs, organotrophs), Mixotrophy and auxotrophy, **Nutrient Uptake Mechanisms:** Passive and facilitated diffusion, **Physiological Adaptations:** Stress responses: heat-shock proteins, acid tolerance, Sporulation, biofilm formation, quorum sensing
Unit 3	**TotalHours**: **12** **Microbial Metabolism – Catabolism, Overview of Microbial Metabolism** Metabolic pathways: amphibolic, catabolic, anabolic, Role of enzymes and coenzymes **Carbohydrate Metabolism,** Glycolysis (EMP pathway), ED pathway, Pentose phosphate pathway (PPP), Fermentation types and end products (lactic, alcoholic, mixed acid), **Respiration in Microbes:** Aerobic vs. anaerobic respiration, TCA cycle and electron transport chain
Unit 4	**Total Hours: 8** **Microbial Metabolism – Anabolism, Biosynthesis of Macromolecules** Synthesis of amino acids and nucleotides, Peptidoglycan and cell wall biosynthesis, Lipid and polysaccharide biosynthesis, **Nitrogen and Sulfur Metabolism,** Nitrogen fixation and ammonification, Nitrification and denitrification, Assimilatory and dissimilatory sulfate reduction, **Photosynthesis in Microorganisms,** Oxygenic vs. anoxygenic photosynthesis Photosynthetic pigments (chlorophylls, bacteriochlorophylls, carotenoids)
Unit 5	**Total Hours:08** **Regulation and Integration of Metabolism,** Enzyme Regulation and Feedback Control Allosteric regulation, Feedback inhibition and repression, Induction (e.g., lac operon) and catabolite repression, **Global Regulatory Mechanisms,** Two-component regulatory systems, Stringent response and sigma factors, Quorum sensing and regulation of gene expression, **Integration of Metabolic Pathways.**

First year;Semester- II

Corepaper: 5 Subject Code: MSMB-201
Title of the paper: Microbial Toxicology
Theory (4 Credit)

Subject	**Microbial Toxicology**
	CO1: Explain microbial toxins, their mechanisms, and host interactions. **CO2:** Differentiate endotoxins, exotoxins, and mycotoxins. **CO3:** Evaluate toxin detection methods and safety assessment. **CO4:** Analyze microbial toxicity impacts on health, agriculture, and environment.
Unit 1	**Total Hours 08** **Introduction to Microbial Toxicology** Definition, scope, and significance of microbial toxicology. Classification of microbial toxins: exotoxins, endotoxins, enterotoxins, neurotoxins, cytotoxins. Structure, biosynthesis, and mode of action of bacterial toxins. Virulence factors: adhesins, invasins, enzymes, and immunomodulators. Host–pathogen interactions and toxin–host cell signaling pathways
Unit 2	**TotalHours:04** **Mechanisms of Toxicity and Immune Responses** Cellular and molecular mechanisms of microbial toxicity. Toxin receptors, membrane interactions, internalization pathways. Immune responses to toxins: innate and adaptive. Toxin neutralization: antitoxins, antibodies, and vaccines. Overview of toxin gene regulation in microbes
Unit 3	**TotalHours: 12** **Types of Microbial Toxins and Their Effects** **Bacterial toxins:** AB toxins (diphtheria, cholera, shiga), Superantigens (TSST, enterotoxins), Endotoxins (LPS structure, mechanism). **Fungal toxins (Mycotoxins):,**Aflatoxins, ochratoxins, fumonisins, ergot alkaloids, Toxic effects and mechanisms **Algal and cyanobacterial toxins:** Microcystins, saxitoxin, domoic acid
Unit 4	**Total Hours: 8** **Environmental and Industrial Toxicology** Microbial toxins in food, water, and environment, Foodborne pathogens and toxin-associated illnesses, Bioremediation of toxic compounds: microbial degradation pathways Industrial processes influenced by microbial toxins, Toxins in agriculture: plant pathogens, phytotoxins, and crop damage, Biosafety levels (BSL) and handling of toxin-producing microbes.
Unit 5	**Total Hours:08** **Applications, Control Measures, and Emerging Concerns** Toxin-based therapeutics, vaccines, and diagnostic kits, Strategies for toxin prevention and control: HACCP, food safety guidelines, Synthetic biology and engineered microbial toxins Emerging issues: bioterrorism agents, antibiotic resistance and toxin regulation, Public health implications of microbial toxins

Firstyear;Semester- II
Corepaper: 5 Subject Code: MSMB-202
Title of the paper: Genomics and Proteomics
Theory (4 Credit)

Subject	**Genomics and Proteomics**
	CO1: Explain genome organization, sequencing platforms, and annotation tools. **CO2:** Analyze transcriptomic and proteomic profiling techniques. **CO3:** Apply bioinformatics in genome and protein data interpretation. **CO4:** Evaluate applications of genomics/proteomics in healthcare and industry.
Unit 1	**Total Hours 08** **Introduction to Genomics:** Genome organization: prokaryotes vs. eukaryotes Genome sequencing methods: Sanger, NGS, Nanopore, Genome mapping, assembly, annotation, Major genome projects (e.g., HGP)
Unit 2	**TotalHours:04** **Functional and Comparative Genomics:** Gene prediction and annotation tools (BLAST, GeneMark), Transcriptomics: microarrays, RNA-Seq, Gene silencing: RNAi, CRISPR Comparative genomics: orthologs, paralogs, evolutionary insights
Unit 3	**TotalHours: 12** **Introduction to Proteomics:** Definition and scope of proteomics, Protein structure, folding, and PTMs, Proteome analysis: 2D-PAGE, Western blot, ELISAMass spectrometry basics (MALDI-TOF, ESI-MS)
Unit 4	**Total Hours: 8** **Advanced Proteomics Techniques:** Quantitative proteomics: iTRAQ, SILAC Protein-protein interactions: Y2H, Co-IP, SPR, Proteomics databases: UniProt, STRING, PDB, Bioinformatics tools for protein modeling and function analysis
Unit 5	**Total Hours:08** **Applications and Emerging Areas,** Genomics in medicine, agriculture, and biomarker discovery, Systems biology and synthetic biology, Genome editing tools: CRISPR/Cas9 Ethical, legal, and social implications (ELSI)

Firstyear;Semester- II
Corepaper: 7 Subject Code: MSMB-203
Title of the paper: Genetic Engineering in Microbes
Theory (4 Credit)

Subject	**Genetic Engineering in Microbes**
	CO1: Explain recombinant DNA technology principles and cloning strategies. **CO2:** Describe vectors, gene editing, and expression systems. **CO3:** Apply genetic engineering tools to manipulate microbial genomes. **CO4:** Evaluate ethical, safety, and regulatory issues in genetic engineering.
Unit 1	**Total Hours 08** **Basics of Genetic Engineering:** History and scope in microbial systems, Central dogma relevance to genetic manipulation, Natural gene transfer in microbes: transformation, transduction, conjugation, **Molecular Tools and Enzymes,** Restriction endonucleases, ligases, polymerases, Modifying enzymes: alkaline phosphatase, nucleases, kinases Reverse transcriptase and its applications.
Unit 2	**TotalHours:04** **Cloning Vectors and Gene Cloning** **Types of Vectors:** Plasmids (pBR322, pUC series), cosmids, phagemids, BACs, YACs Shuttle vectors and expression vectors, **Gene Cloning Techniques:** Construction of recombinant DNA, Transformation and selection methods (blue-white screening, antibiotic resistance), Host systems: *E. coli*, *Saccharomyces cerevisiae*, *Bacillus subtilis* **Confirmation and Analysis of Clones,** Colony PCR, restriction mapping, sequencing Reporter genes and marker systems (e.g., GFP, LacZ)
Unit 3	**TotalHours: 12** **Expression of Recombinant Proteins, Expression Systems in Microbes** Prokaryotic systems: *E. coli* expression hosts (advantages and limitations), Eukaryotic systems: yeast, fungal expression, Inducible and constitutive promoters (e.g., lac, T7, arabinose operon) **Optimization of Protein Expression:** Codon optimization, Inclusion bodies and refolding techniques, Affinity tags and purification strategies (His-tag, GST-tag)
Unit 4	**Total Hours: 8** **Genome Editing Technologies:** CRISPR-Cas system in microbial gene editing, TALENs, ZFNs – principles and microbial applications, **Site-Directed Mutagenesis and Gene Knockouts,** Techniques and applications in metabolic pathway engineering Markerless gene deletion systems, **Synthetic Biology in Microbes:** Gene circuits and biosynthetic pathway design, Engineering microbes for novel product synthesis (e.g., biofuels, drugs)
Unit 5	**Total Hours:08** **Applications and Biosafety, Applications of Genetic Engineering in Microbes** Recombinant enzymes, biofertilizers, biopesticides, GM microbes for bioremediation, Vaccine development and diagnostics (e.g., recombinant antigens) **Regulations and Biosafety,** Containment levels and GMO risk assessment, National and international guidelines (DBT, NIH, WHO, Cartagena Protocol), Intellectual property rights and ethical considerations

Firstyear;Semester- II
Corepaper: 8 Subject Code: MSMB-204
Title of the paper: Biostatistics and Bioinformatics

Theory (4 Credit)

Subject	Biostatistics and Bioinformatics
	CO1: Apply statistical methods for biological data analysis. CO2: Use computational tools for sequence alignment and phylogenetic analysis. CO3: Interpret large biological datasets using appropriate statistical tools. CO4: Integrate biostatistics with bioinformatics for experimental design.
Unit 1	**Total Hours 08** **Introduction to Biostatistics:** Basics of Biostatistics, Scope and applications in life sciences: Types of data: qualitative vs. quantitative, nominal, ordinal, discrete, continuous Measures of central tendency: mean, median, mode, Measures of dispersion: range, variance, standard deviation, coefficient of variation Data Presentation, Tabulation and graphical representation: bar charts, histograms, pie charts, box plots, Frequency distributions and cumulative frequency curves
Unit 2	**TotalHours:04** **Probability and Statistical Inference** Probability Concepts: Basic probability rules, conditional probability, Probability distributions: binomial, Poisson, and normal, Sampling and Hypothesis Testing, Sampling methods: random, stratified, systematic, Standard error, confidence intervals, Hypothesis testing: null and alternative hypotheses, Type I and II errors, t-test, z-test, chi-square test, ANOVA (one-way and two-way), Correlation and Regression, Pearson and Spearman correlation, Simple and multiple linear regression analysis
Unit 3	**TotalHours: 12** **Introduction to Bioinformatics: Basics and Scope** Definition and applications in genomics, proteomics, drug discovery, Types of biological databases: primary, secondary, specialized, Nucleotide and protein databases: GenBank, EMBL, DDBJ, UniProt, PDB, Sequence file formats: FASTA, GenBank, Clustal **Biological Data Retrieval and Analysis,** Database searching using NCBI, EBI, and ExPASy portals, Data mining and text mining in bioinformatics
Unit 4	**Total Hours: 8** **Sequence Alignment and Phylogenetics** **Sequence Alignment:** Pairwise alignment: global (Needleman–Wunsch) and local (Smith–Waterman), Multiple sequence alignment (MSA): Clustal Omega, MUSCLE, Scoring matrices: PAM, BLOSUM, BLAST and FASTA tools for similarity searching **Phylogenetic Analysis,** Concepts of evolutionary relationships, Construction of phylogenetic trees: UPGMA, Neighbor-Joining, Maximum Parsimony, Bootstrapping and tree evaluation
Unit 5	**Total Hours:08** **Genomics, Proteomics, and Computational Tools** **Genomics and Transcriptomics Tools:** Genome annotation, SNP analysis, RNA-Seq and microarray data analysis, **Proteomics Tools:** Protein structure prediction: homology modeling, ab initio methods, Tools: SWISS-MODEL, PDB, RASMOL, PyMOL, Protein function prediction and domain analysis

II YEAR

SEM:III							
Batch:2025-26							**SEM:III**
S.No.	**Course Type**	**Course Code**	**Course Name**	**Teaching Load**			**Credits**
				L	**T**	**P**	
THEORY and PRACTICAL SUBJECTS							
1	Core Course 9	MSMB-301	Plant Biotechnology	4	0	0	4
2	Core Course 10	MSBT-302	Industrial Microbiology	4	0	0	4
3	DEC 1	MSMB-303A/B	Bacteriology and Virology/Medical Microbiology	4	0	0	4
4	DEC 2	MSMB-304A/B,	Environmental Microbiology/Industrial microbiology	4	0	0	4
5	Practical V (Based on CC 9 & 10)	MSMB-305P	Practical based on MSMB-301	0	0	4	4
6	Practical VI (Based on DEC 1 & 2)	MSMB-306P	Practical based on MSMB-302	0	0	4	4
7	OEC 1	MSMB-307	Choose from Bucket	2	0	0	2
TOTAL CREDITS / ASSESSMENT							**26**

SEM:IV (With Project Work)							
Batch:2025-26				**SEM:IV (Without Project Work)**			
S.No.	**Course Type**	**Course Code**	**Course Name**	**Teaching Load**			**Credits**
				L	**T**	**P**	
THEORY and PRACTICAL SUBJECTS							
1	Core Course 11	MSMB-401	Nano-Microbiology	4	0	0	4
2	DEC 5	MSMB-402A/B	Genomics and Proteomics/ Pharmaceutical Microbiology	4	0	0	4
3	DEC 6	MSMB-403A/B	Epidemiology/ Research Methodologies and Scientific Writing	4	0	0	4
5	EEC 1		Choose from Bucket	4	0	0	2
6	Project Work (Dissertation)	MSMB-404D		0	0	4	12
TOTAL CREDITS / ASSESSMENT							**26**

Second year;Semester- III
Corepaper: 9 Subject Code: MSMB-301
Title of the paper: Plant Biotechnology
Theory (4 Credit)

Subject	**Plant Biotechnology**
	CO1: Explain tissue culture principles and plant regeneration pathways. **CO2:** Describe genetic transformation methods in plants. **CO3:**Analyze applications of plant biotechnology in agriculture and industry. **CO4:** Evaluate biosafety issues and regulatory frameworks in plant biotech.
Unit 1	**Total Hours 08** **Fundamentals of Plant Biotechnology:** Scope and applications of plant biotechnology in agriculture and industry, Plant tissue culture: principles, totipotency, and micropropagation Callus, suspension, and organ cultures, Role of microbes in plant tissue culture (endophytes, contamination control).
Unit 2	**TotalHours:04** **Plant-Microbe Interactions:** Rhizosphere microbiology and microbial ecology Symbiotic associations: Rhizobium–legume nitrogen fixation, Mycorrhizae: types and benefits, Endophytes and their role in plant health, Plant growth-promoting rhizobacteria (PGPR): mechanisms and biofertilizer potential, Pathogenic interactions: Agrobacterium, fungal and viral pathogens
Unit 3	**TotalHours: 12** **Genetic Engineering in Plants (Microbial Tools Focus):** Agrobacterium-mediated gene transfer: Ti plasmid, T-DNA integration, Use of microbial vectors: Agrobacterium, viral vectors, Gene gun and other transformation methods, Reporter genes (GUS, GFP) and selectable markers (kanamycin resistance), Applications: disease resistance, abiotic stress tolerance, quality improvement.
Unit 4	**Total Hours: 8** **Plant Biotechnology Applications Using Microbes** Biofertilizers: nitrogen fixers (*Azospirillum*, *Rhizobium*, *Frankia*), phosphate solubilizers, Biopesticides: *Bacillus thuringiensis*, *Trichoderma*, viral biocontrol agents, Phytoremediation with microbial aid, Use of genetically engineered microbes in plant health and productivity
Unit 5	**Total Hours:08** **Molecular and Omics Approaches in Plant-Microbe Systems:** Plant-microbe signaling molecules (flavonoids, Nod factors), Molecular markers in plant-microbe studies (RAPD, AFLP, SSR), Transcriptomics and proteomics of plant–microbe interactions, Genome editing in plants using CRISPR/Cas (with microbial vector systems), Bioinformatics in plant-microbe interaction studies.

Second year;Semester- III
Corepaper: 10 Subject Code: MSMB-302
Title of the paper: Industrial Microbiology
Theory (4 Credit)

Subject	**Industrial Microbiology**
	CO1: Explain industrially important microbes and fermentation principles. **CO2:** Describe bioprocess operation and product recovery. **CO3:** Analyze upstream and downstream processing. **CO4:** Evaluate applications of microbes in food, pharma, and biotech industries.
Unit 1	**Total Hours 08** **Fundamentals of Industrial Microbiology:** Introduction and Scope, Historical development and significance, Role of microbes in industrial processes, Primary vs. secondary metabolites, **Screening of Industrial Microorganisms,** Primary and secondary screening methods, Strain improvement: mutation, recombination, genetic engineering Preservation of industrial strains (slants, lyophilization, cryopreservation)
Unit 2	**TotalHours:04** **Fermentation Technology;** Types: batch, fed-batch, continuous Upstream processing: media formulation, sterilization, inoculum development, Bioreactor design and types (stirred tank, airlift, packed bed) **Downstream Processing** Cell harvesting, extraction, purification (filtration, centrifugation, chromatography), Product recovery and formulation
Unit 3	**TotalHours: 12** **Industrial Production of Microbial Products:** Microbial Enzymes, Amylases, proteases, cellulases, lipases – production and applications, Antibiotics and Therapeutics, Production of vaccines and recombinant therapeutics (insulin, interferon), Organic Acids and Alcohols, Citric acid, lactic acid, acetic acid, Ethanol and butanol fermentation.
Unit 4	**Total Hours: 8** **Food, Beverage, and Dairy Microbiology:** Microbial Fermentation in Food, Fermented foods: pickles, sauerkraut, soy products, Probiotics and functional foods, Dairy Industry Applications, Fermented dairy products: yogurt, cheese, buttermilk, Starter cultures and their maintenance, Alcoholic Beverages, Beer, wine, and spirit production, Role of *Saccharomyces cerevisiae* and lactic acid bacteria.
Unit 5	**Total Hours:08** **Environmental and Modern Applications:** Microbes in Waste Management and Bioremediation, Sewage treatment: aerobic and anaerobic systems, Biodegradation and composting microbes, Biofertilizers and Biopesticides, Nitrogen fixers (*Rhizobium*, *Azospirillum*), phosphate solubilizers, Biocontrol agents (*Bacillus thuringiensis*, *Trichoderma*), Emerging Technologies, Immobilized enzymes and cells,Industrial application of extremophiles, Microbial production of bioplastics and biofuels (biodiesel, methane, hydrogen).

Second year;Semester- III
DEC: 01 Subject Code: MSMB-303A

Title of the paper: Bacteriology and Virology
Theory (4 Credit)

Subject	**Bacteriology and Virology**
	CO1: Explain structure, taxonomy, and physiology of bacteria and viruses. **CO2:** Describe viral replication, pathogenicity, and bacteriophage biology. **CO3:** Apply diagnostic approaches for bacterial and viral diseases. **CO4:** Evaluate emerging pathogens and control strategies.
Unit 1	**Total Hours 08** **Basics of Bacteriology & Classification (8 Hours)** • History and scope of bacteriology. • General characteristics of bacteria. • Classification and nomenclature (Bergey's Manual). • Major bacterial groups: Gram-positive, Gram-negative, Archaea, Mycoplasma, Chlamydia, Rickettsia, Actinomycetes, Cyanobacteria.
Unit 2	**TotalHours:08** **Bacterial Structure &Physiology :**Ultrastructure: Cell wall types, capsules, pili, flagella, endospores, S-layers. Cytoplasmic membrane, ribosomes, nucleoid, plasmids., Bacterial growth: Growth curve, measurement methods, factors influencing growth. Metabolism: Carbohydrate, protein, and lipid metabolism; fermentation types; respiration; chemolithotrophy; phototrophy. Biofilms: Formation, structure, clinical importance.
Unit 3	**TotalHours: 12** **Introduction to Virology & Viral Architecture** • History and scope of virology. • Nature and properties of viruses. • Viral classification (ICTV): DNA, RNA, enveloped, non-enveloped, retroviruses. • Structure and symmetry: Icosahedral, helical, complex viruses.
Unit 4	**Total Hours: 8** Virulence factors: Adhesins, invasins, toxins (endotoxin/exotoxin)., Mechanisms of pathogenesis and bacterial invasion. Normal microbiota: Role in health and disease. Biosecurity and biosafety levels. Mechanisms of antimicrobial action: Cell wall inhibitors, protein synthesis inhibitors, DNA/RNA inhibitors. Antibiotic resistance: Mechanisms (ESBL, MRSA, VRSA, CRE, efflux pumps)
Unit 5	**Total Hours:08** **Host–Virus Interaction & Immunology** • Pathogenic mechanisms of viruses. • Acute, persistent, latent, slow infections. • Oncogenic viruses. • Antiviral immunity: Innate and adaptive responses. • Mechanisms of immune evasion by viruses. • Interferons and antiviral agents.

Second year;Semester- III
DEC: 02 Subject Code: MSMB-303 B

Title of the paper: Environmental Microbiology
Theory (4 Credit)

Subject	**Environmental Microbiology**
	CO1: Explain microbial roles in soil, water, and air ecosystems. **CO2:** Describe biogeochemical cycles and microbial interactions. **CO3:** Apply microbial techniques in pollution monitoring and bioremediation. **CO4:** Evaluate environmental impacts of microbial processes.
Unit 1	**Total Hours 08** **Introduction to Environmental Microbiology:** Scope and importance of environmental microbiology, Microbial diversity in natural environments: soil, water, air, Microbial ecology: niche, habitat, population, community, and ecosystem, Microbial interactions: mutualism, commensalism, parasitism, competition, predation, Role of microorganisms in biogeochemical cycles (C, N, S, P).
Unit 2	**TotalHours:04** **Microbial Communities and Environmental Monitoring** Methods for studying microbial communities: culture-dependent and -independent approaches, Metagenomics, DGGE, FISH, 16S rRNA sequencing, Indicators of water, air, and soil quality, Biosensors and molecular markers for environmental monitoring, Bioindicators and bioreporters.
Unit 3	**TotalHours: 12** **Soil and Aquatic Microbiology:** Soil microbiome: structure, function, and nutrient cycling, Rhizosphere, phyllosphere, and endophytic microbes, Microbiology of freshwater and marine systems, Microbial role in wastewater treatment: primary, secondary, tertiary treatment, Activated sludge, trickling filters, anaerobic digester.
Unit 4	**Total Hours: 8** **Microbial Degradation and Bioremediation** Microbial degradation of natural and xenobiotic compounds, Hydrocarbon-degrading microbes and oil spill management, Heavy metal and plastic biodegradation, Bioremediation strategies: in situ, ex situ, phytoremediation, mycoremediation, Bioaugmentation and bio stimulation.
Unit 5	**Total Hours:08** **Environmental Biotechnology and Applied Aspects:** Microbes in solid waste management and composting, Microbial production of biofertilizers and biopesticides Biogas and biofuel production from microbial consortia,Global environmental issues: climate change, microbial indicators of pollution, Microbial role in sustainable development and ecosystem restoration.

Second year;Semester- IV
Core Paper: 11 Subject Code: MSMB-401
Title of the paper: Nano-Microbiology
Theory (4 Credit)

Subject	**Nano-Microbiology**
	CO1: Explain interaction of microbes with nanomaterials. **CO2:** Describe microbial synthesis of nanoparticles.

	CO3: Analyze applications of nanotechnology in microbial detection and control. **CO4:** Evaluate biosafety and environmental implications of nanomaterials.
Unit 1	**Total Hours 08** Fundamentals of Nanoscience and Nanotechnology: Introduction to nanoscience and nanotechnology, Properties of nanomaterials: physical, chemical, optical, electrical, Classification of nanomaterials: carbon-based, metal-based, polymers, composites, Concepts of size, shape, surface area, and quantum effects, Overview of nanoscale characterization tools: SEM, TEM, AFM, DLS, XRD
Unit 2	**TotalHours:04** **Microbial Interactions with Nanomaterials:** Microbial synthesis of nanoparticles (green synthesis), Bacteria, fungi, actinomycetes, algae-based synthesis. Mechanisms of microbial nanoparticle production: intracellular, extracellular pathways, Factors influencing microbial nanoparticle synthesis (pH, temperature, substrate), Microbe-nanoparticle interaction: uptake, toxicity, and resistance mechanisms.
Unit 3	**TotalHours: 12** **Applications of Nanotechnology in Microbiology:** Antimicrobial activity of metal/metal oxide nanoparticles (Ag, ZnO, TiO_2, CuO), Nanomaterials in diagnostics: nanosensors, quantum dots, biosensors, Nanotechnology in microbial detection and pathogen identification, Nanoformulations in drug delivery and antimicrobial therapy, Nanoscale approaches to biofilm inhibition and eradication.
Unit 4	**Total Hours: 8** **Environmental and Industrial Applications:** Nanoparticles in water and wastewater treatment, Microbial nanotechnology in bioremediation and pollutant degradation, Use of nano-biofertilizers and nanopesticides, Role of microbes in nano-mineralization and nano-bioreactors, Nanomaterials for food packaging and preservation.
Unit 5	**Total Hours:08** **Safety, Toxicity, and Ethical Aspects** Nanotoxicology: mechanisms of nanoparticle-induced microbial toxicity, Environmental impact and fate of nanomaterials, Risk assessment and biosafety of nano-bio interactions Regulatory frameworks (OECD, EPA, DBT, WHO), Ethical and societal implications of nano-microbiology.

Secondyear;Semester- IV
DEC paper: 4 Subject Code: MSMB-402A
Title of the paper: Genomics and Proteomics
Theory (4 Credit)

Subject	**Genomics and Proteomics**
	CO1: Explain advanced genome editing and omics technologies. **CO2:** Analyze high-throughput sequencing and proteomic profiling. **CO3:** Apply bioinformatics for system-level biological interpretation. **CO4:** Evaluate applications of omics in precision medicine and biotechnology.
Unit 1	**Total Hours 08** **Introduction to Genomics:** Genome organization: prokaryotes vs. eukaryotes

	Genome sequencing methods: Sanger, NGS, Nanopore, Genome mapping, assembly, annotation, Major genome projects (e.g., HGP)
Unit 2	**TotalHours:04** **Functional and Comparative Genomics:** Gene prediction and annotation tools (BLAST, GeneMark), Transcriptomics: microarrays, RNA-Seq, Gene silencing: RNAi, CRISPR Comparative genomics: orthologs, paralogs, evolutionary insights
Unit 3	**TotalHours: 12** **Introduction to Proteomics:** Definition and scope of proteomics, Protein structure, folding, and PTMs, Proteome analysis: 2D-PAGE, Western blot, ELISAMass spectrometry basics (MALDI-TOF, ESI-MS)
Unit 4	**Total Hours: 8** **Advanced Proteomics Techniques:** Quantitative proteomics: iTRAQ, SILAC Protein-protein interactions: Y2H, Co-IP, SPR, Proteomics databases: UniProt, STRING, PDB, Bioinformatics tools for protein modeling and function analysis
Unit 5	**Total Hours:08** **Applications and Emerging Areas,** Genomics in medicine, agriculture, and biomarker discovery, Systems biology and synthetic biology, Genome editing tools: CRISPR/Cas9 Ethical, legal, and social implications (ELSI)

Second year;Semester- IV
DEC Paper: 05 Subject Code: MSMB-402B
Title of the paper: Pharmaceutical Microbiology
Theory (4 Credit)

Subject	**Pharmaceutical Microbiology**
	CO1: Explain role of microbes in drug development and manufacturing. **CO2:** Describe sterilization, preservation, and aseptic processing. **CO3:** Analyze antimicrobial testing and quality control methods. **CO4:** Evaluate regulatory guidelines and contamination control.
Unit 1	**Total Hours 08** **Introduction to Pharmaceutical Microbiology** Scope and significance of pharmaceutical microbiology, Classification of pharmaceutical products: sterile, non-sterile, biologicals, Sources and control of microbial contamination in pharmaceutical environments, Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP), Regulatory bodies: WHO, FDA, EMA, CDSCO.
Unit 2	**TotalHours:04** **Microbial Contamination and Preservation:** Microbial contamination in pharmaceuticals: raw materials, water, air, packaging, Microbial limits and specifications for pharmaceutical products, Sterility testing: methods, media, and validation, Preservatives: types, mechanisms, and efficacy testing (preservative challenge test),

	Cleanroom classifications and air handling systems.
Unit 3	**TotalHours: 12** **Sterilization and Disinfection:** Principles and types of sterilization: Physical methods: moist heat (autoclave), dry heat, filtration, radiation, Chemical sterilants and gaseous sterilization, Validation of sterilization processes (biological indicators), Disinfectants: types, mechanisms of action, evaluation (Rideal-Walker, phenol coefficient), Factors affecting efficacy and resistance development.
Unit 4	**Total Hours: 8** **Microbial Assays and Antibiotic Production** Microbiological assay of antibiotics: agar diffusion, turbidimetric methods, Determination of MIC and MBC, Production of antibiotics (*Penicillin*, *Streptomycin*, *Cephalosporins*), Screening and strain improvement of antibiotic-producing microbes, Quality control of antibiotics and other microbial drugs.
Unit 5	**Total Hours:08** **Biotechnology and Advanced Topics in Pharmaceutical Microbiology** Recombinant pharmaceuticals: production of insulin, vaccines, monoclonal antibodies Probiotics and prebiotics in therapy, Microbial enzymes and secondary metabolites in drug formulations, Biosafety and risk assessment in pharmaceutical biotechnology, Emerging areas: nanopharmaceuticals, microbiome-based therapeutics, personalized medicine.

Second year;Semester- IV
DEC Paper: 06 Subject Code: MSMB-403A
Title of the paper: Epidemiology
Theory (4 Credit)

Subject	**Epidemiology**
COs	**CO1:** Explain epidemiological concepts, disease spread, and surveillance. **CO2:** Analyze epidemiological data using appropriate measures and models. **CO3:** Apply methods for outbreak investigation and control. **CO4:** Evaluate public health strategies and preventive measures.
Unit 1	**Total Hours 08** **Introduction to Epidemiology:** Definition, scope, and importance of epidemiology Historical perspectives: major outbreaks and milestones, Concepts: endemic, epidemic, pandemic, sporadic, Natural history and spectrum of disease, Host–agent–environment triad and chain of infection.
Unit 2	**TotalHours:04** **Measures in Epidemiology:** Measures of disease frequency: incidence, prevalence, attack rate, Measures of association: risk ratio, odds ratio, attributable risk, Mortality rates: crude, specific, case fatality rate, Standardization of rates: direct and indirect methods, Epidemic curves and interpretation.
Unit 3	**TotalHours: 12** Study Designs in Epidemiology: Observational studies: Descriptive studies (case reports, case series), Analytical studies: cross-sectional, case-control, cohort studies, Experimental studies: randomized controlled trials (RCTs), field trials, Bias, confounding, and effect modification, Sampling methods and sample size estimation.

Unit 4	**Total Hours: 8** **Disease Surveillance, Investigation, and Control** Surveillance systems: passive, active, sentinel, syndromic, Steps in outbreak investigation Screening vs. diagnostic testing: sensitivity, specificity, predictive values, Prevention levels: primary, secondary, tertiary, Vaccination strategies and herd immunity.
Unit 5	**Total Hours:08** **Applied and Molecular Epidemiology** Epidemiology of communicable diseases (e.g., TB, HIV, COVID-19, malaria), Epidemiology of non-communicable diseases (e.g., cancer, diabetes, cardiovascular diseases), Antimicrobial resistance (AMR) tracking and epidemiology, Molecular tools in epidemiology: PFGE, MLST, WGS, GIS mapping, Global health organizations: WHO, CDC, ICMR, ECDC – roles and functions

Second year;Semester- IV
DEC Paper: 08 Subject Code: MSMB-403B
Title of the paper: Research Methodology and Scientific Communications
Theory (4 Credit)

Subject	**Research Methodology and Scientific Communications**
COs	**CO1:** Explain research design, hypothesis formation, and data collection methods. **CO2:** Apply statistical tools for data analysis and interpretation. **CO3:** Develop scientific writing skills for reports, papers, and presentations. **CO4:** Evaluate ethics in research and publication processes.
Unit 1	**Total Hours 08** **Introduction to Research Methodology** • Meaning, purpose, and significance of research in microbiology. • Types of research: Basic, applied, qualitative, quantitative, experimental, descriptive, translational. • Structure and characteristics of scientific research. • Identification and formulation of research problems. • Research questions, aims, objectives, variables and hypothesis types. • Research design: Exploratory, experimental, cross-sectional, longitudinal, case-control, cohort.
Unit 2	**TotalHours:04** **Literature Review and Research** • Sources of scientific literature: Primary, secondary, tertiary sources. • Databases: PubMed, Scopus, Web of Science, Google Scholar, NCBI tools. • Search strategies, Boolean operators, impact factor, h-index. • Reference management software: Mendeley, Zotero, EndNote. • Plagiarism: Definition, types, tools for detection (Turnitin, Thenticate).
Unit 3	**TotalHours: 12** **Experimental Methods & Data Handling** • Sampling methods: Probability and non-probability sampling. • Laboratory experiment design; controls, replicates, standardization. • Good Laboratory Practices (GLP).

	• Data collection, organization, classification. • Data representation: Tables, graphs, charts. • Use of Excel/SPSS/R for basic statistical analysis.
Unit 4	**Total Hours: 8** **Biostatistics in Research** • Measures of central tendency and dispersion. • Probability distributions: Normal, Poisson, binomial. • Parametric tests: t-test, ANOVA. • Non-parametric tests: Chi-square, Mann–Whitney. • Correlation and regression analysis.
Unit 5	**Total Hours:08** **Scientific Writing & Communication** • Structure of a scientific paper: Title, abstract, introduction, materials & methods, results, discussion, references. • Writing research proposals, dissertations, theses, project reports. • Review articles vs. research articles.