ANNEXURE – III C

DAYANANDA SAGAR UNIVERSITY

SCHOOL OF BASIC & APPLIED SCIENCES

SCHEME & SYLLABUS
FOR
MASTER OF SCIENCE (M.Sc.) – 2025-2027

SPECIALIZATION: MICROBIOLOGY

(With effect from 2025-26)

(From I to IV Semesters)

DAYANANDA SAGAR UNIVERSITY

INNOVATION CAMPUS, KUDLU GATE, HOSUR ROAD,
BENGALURU -560114.

DAYANANDA SAGAR UNIVERSITY
SCHOOL OF BASIC AND APPLIED SCIENCES
SCHEME- M. SC. MICROBIOLOGY- 2025-26 ONWARDS
I SEM – M.Sc.- MICROBIOLOGY

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
					L	T	P	S/P	C	CIA	SEE
1	208	25MSC5101	Essentials of Chemistry	CR	4	-	-	-	4	60	40
2	208	25MMB5101	Biomolecules and Enzymology	CR	4	-	-	-	4	60	40
3	208	25MMB5102	Prokaryotic Microbiology	CR	4	-	-	-	4	60	40
4	208	25MMB5103	Eukaryotic Microbiology	CR	4	-	-	-	4	60	40
5	208	25MMB5104	Microbial techniques: Principles and Practices	CR	2	-	-	-	2	60	40
6	208	25MSC5102	Biostatistics	CR	2	-		-	2	60	40
7	208	25MMB5171	Techniques in Enzymology and Biological Chemistry	CR	-	-	6	-	3	60	40
8	208	25MMB5172	Basic Microbiological Techniques	CR	-	-	6	-	3	60	40
Grand Total= 700					**20**		**12**		**26**	**420**	**280**

CR – Credit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

II SEM – M.Sc. – MICROBIOLOGY

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
					L	T	P	S/P	C	CIA	SEE
1	208	25MMB5201	Microbial Physiology	CR	4	-	-	-	4	60	40
2	208	25MMB5202	Microbial Genetics and Molecular Biology	CR	4	-	-	-	4	60	40
3	208	25MMB5203	Immunology and Medical Microbiology	CR	4	-	-	-	4	60	40
4	208	25MMB5204	Environmental Microbiology	CR	4	-	-	-	4	60	40
5	208	25MMB5205	Agricultural Microbiology and Plant Pathology	CR	4	-	-	-	4	60	40
6	208	25MMB5206	Bioinformatics	CR	2	-		-	2	60	40
7	208	25MMB5271	Techniques in Microbial Physiology, Immunology and Medical Microbiology	CR	-	-	6		3	60	40
8	208	25MMB5272	Techniques in Agricultural and Environmental Microbiology	CR	-	-	6		3	60	40
Grand Total= 800					**22**		**12**		**28**	**480**	**320**

CR – Credit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

III SEM – M.Sc. – MICROBIOLOGY

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
					L	T	P	S/P	C	CIA	SEE
1	208	25MMB5301	Genetic Engineering and rDNA technology	CR	4	-	-	-	4	60	40
2	208	25MMB5302	Industrial, Food and Dairy Microbiology	CR	4	-	-	-	4	60	40
3	208	25MMB5303	Advanced Microbiology	CR	3	-	-	-	3	60	40
4	208	25MMB5304	Translational Microbiology	CR	3	-	-	-	3	60	40
5	208	25MMB5305	Advanced Microbiological Techniques	CR	3	-	-	-	3	60	40
6	208	25MSC5301	Research Methodology, Scientific Writing and IPR	CR	3	-	-	-	2	60	40
7	208	25MMB5306	Multiomics	CR	2	-	-	-	2	60	40
8	208	25MMB5307	Clinical Research	CR	2	-	-	-	2	60	40
9	208	25MMB5371	Advanced Techniques in Microbiology	CR	-	-	6	-	3	60	40
10	208	25MMB5372	Advances in Bioprocess Technology	CR	-	-	6	-	3	60	40
Grand Total= 1000					**24**		**12**		**30**	**600**	**400**

CR – Credit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

IV SEM – M.Sc. – MICROBIOLOGY

SL	PROGRAM CODE	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
					L	T	P	S/P	C	CIA	SEE
1	208	**25MSC5401**	**Project**	**CR**	**-**	**-**	**36**	**-**	**14**		
2	208	**25MSC5402**	**MOOC/NPTEL/ Swayam**	**CR**	**2**	**-**	**-**	**-**	**2**		
Grand Total= 400					**-**	**-**	**36**	**-**	**16**	**240**	**160**

CR – Credit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

SL	CREDIT (CR)	MARKS	
		CIA MARKS	END EXAM MARKS
1	4	60	40
2	3	60	40
3	2	30	20
4	14	240	160

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MSC5101**					
TITLE OF THE COURSE	**ESSENTIALS OF CHEMISTRY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To help students grasp fundamental chemical principles—such as stoichiometry, chemical bonding, electrochemistry, and organic reactivity—specifically as they relate to biological systems.
- To enable students to apply theoretical knowledge in solving quantitative and mechanistic problems involving solution chemistry, redox reactions, and biomolecular interactions.
- To introduce students to the chemical structures and reaction mechanisms within biological contexts, including enzymatic catalysis, metabolic pathways, and molecular transport.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	Students will become familiar with fundamental chemical concepts, including mole calculations, acid-base theories, bonding types, and stereochemistry, particularly as they apply to biological molecules.	L2
CO2	Students will be able to apply chemical equations and quantitative tools—such as dilution formulas (e.g., N1V1=N2V2) and the Henderson-Hasselbalch equation—along with mechanistic understanding, to tasks such as buffer preparation, molecular weight determination.	L3
CO3	Students will be able to analyze the roles of metals in biological systems, the influence of stereochemistry on bioactivity, and reaction mechanisms related to metabolic processes.	L3

COURSE CONTENT:

MODULE 1: STOICHIOMETRY AND CHEMICAL BONDING **14Hrs**

Stoichiometry: Atomic weights, molecular weights, mole concept, molarity, molality, normality, mole fraction, ppt, ppb and ppm. Numerical problems related to the above concepts. Classification, preparation and dilution of reagents/solutions. Preparation of ppm level solutions from source materials (salts), conversion factors.

Chemical bonding: Ionic bonds, Covalent bonds, Vander walls forces, Electrostatic interactions, Hydrophobic interactions, Hydrogen bonding & their relevance in biological systems, importance of water in biological systems. Coordination bonds in biomolecules - bonding of iron in haemoglobin, magnesium in chlorophyll. Types of chemical bonds in biological molecules (Glycosidic, phosphdiester, peptide).

MODULE 2: PHYSICAL CHEMISTRY	**14Hrs**

Bio-Electrochemistry: Oxidation and Reduction reactions, Electrode potential, standard & reference electrode, calculation of biological standard potential & biological equilibrium constant, Nernst's' equation. Biological electrochemical series (ETC).

Liquids and solutions: Acid and bases (Brønsted-Lowry Theory, Lewis Theory), pKa, pKb, pH, pOH, preparation of buffers, Henderson-Hasselbalch equation and numerical problems associated with buffer preparation. Density and Relative Density, Viscosity, Surface tension, Colligative properties (brief). Calculation of molecular weight of proteins and nucleic acids.

MODULE 3: BIOINORGANIC CHEMISTRY	**14Hrs**

Stereochemistry: Introduction, Different types of isomerism, chirality & optical activity (enatiomers and diastereoisomers; Fischer, Sawhorse, and Newman Projection formulae of simple molecules containing one and two asymmetric carbon atom). Symmetry elements, E and Z, D and L nomenclature (for carbohydrates and aminoacids only).

Role of metals: Introduction, Classification, role of metal in various biological system: Enzyme Activity (zinc with carbonic anhydrase) Examples for metal activated enzymes and metalloenzymes, Energy Transfer and Redox Reactions (cytochrome c complex- Fe), Oxygen Transport (Iron in hemoglobin, Copper in hemocyanin) Nerve Signal Transmission (role of Sodium and potassium ions), Structural Roles, Metallothionins, metals as essential nutrients, nutritional Immunity. Regulatory Roles (Magnesium and calcium ions play crucial roles in cell regulation and signalling pathways.

MODULE 4: BIOORGANIC CHEMISTRY	**14Hrs**

Basics: Properties of carbon, brief classification of organic compounds based on functional groups with examples. Delocalisation of electrons: Inductive effect, electrometric effect, resonance (mesomeric effect, EWG and EDG, +M and –M effects). Curly arrow rules in representation of mechanistic steps, types of bond cleavage; electrophiles, nucleophiles, Reactive intermediates: carbocations, carbanions, free radicals and carbenes– generation, structures, stability and examples.

Reaction mechanisms: SN1 (formation of PRPP in nucleotide biosynthesis), SN2 (eg. DNA polymerization, phosphorylation), E1 (histidine/aromatic aminoacid biosynthesis), E2 reactions (fatty acid biosynthesis). Metabolic reactions- aldol condensation (collagen), esterification of acids (triglycerides), oxidation and reduction reactions (NAD^+ to NADH during cellular respiration.).

REFERENCES:

1. General Chemistry (2022) Linus Pauling, Dover Publications, New York, USA.
2. Quantitative Chemical Analysis 10th Edition (2022) Daniel C. Harris, Macmillan Learning, New York, USA.
3. Lehninger Principles of Biochemistry 8th Edition (2021) David L. Nelson and Michael M. Cox, W.H. Freeman & Company, New York, USA.
4. Physical Chemistry for the Life Sciences 2nd Edition (2014) Peter Atkins and Julio de Paula, Oxford University Press, Oxford, UK.
5. Principles of Physical Chemistry (2023) Puri, Sharma, and Pathania, Vishal Publishing Co., Jalandhar, India.

6. Biophysical Chemistry: Principles and Techniques (2022) Upadhyay, Upadhyay, and Nath, Himalaya Publishing House, Mumbai, India.
7. Bioinorganic Chemistry: A Short Course 2nd Edition (2014) Rosette M. Roat-Malone, Wiley, Hoboken, USA.
8. Inorganic Chemistry 6th Edition (2021) Gary L. Miessler, Paul J. Fischer, and Donald A. Tarr, Pearson Education, Boston, USA.
9. Stereochemistry of Organic Compounds 1st Edition (1994) Ernest L. Eliel and Samuel H. Wilen, Wiley India Pvt. Ltd., New Delhi, India.
10. Organic Chemistry 9th Edition (2021) Paula Yurkanis Bruice, Pearson Education, Boston, USA.
11. Organic Chemistry 8th Edition (2022) Morrison and Boyd, Pearson India Education Services Pvt. Ltd., Noida, India.
12. Principles of Biochemistry 8th Edition (2021) David L. Nelson and Michael M. Cox, W.H. Freeman & Company, New York, USA.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MMB5101**					
TITLE OF THE COURSE	**BIOMOLECULES AND ENZYMOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- This course provides an in-depth understanding of the structure, types, functions, and metabolic pathways of essential biomolecules, including carbohydrates, lipids, amino acids, and proteins.
- To equip students with knowledge of various types of biomolecules in diverse microbes.
- A strong emphasis is placed on the enzymology of protein-mediated reactions, crucial for microbial life processes

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to describe the structure, properties, and biological functions of carbohydrates, lipids, amino acids, and proteins.	L1
CO2	Students will be able to apply knowledge of biomolecules and metabolism to understand microbial physiology and biotechnology.	L3
CO3	Students will be able to understand the principles of enzyme kinetics and enzyme-catalyzed reactions.	L2

COURSE CONTENT:

MODULE 1: CARBOHIDRATES **14Hrs**

Classification and types: Overview of carbohydrates: Definition, classification Monosaccharides (glucose, fructose, galactose) and their stereochemistry; Disaccharides (sucrose, lactose, maltose) and polysaccharides: Homopolysaccharides (glycogen, starch like polymer in bacteria and fungi) and structural polysaccharides (eg cellulose, chitin, beta-glucans) and heteropolysaccharides (LPS in Gram negative, teichoic and teichuronic acids in Gram positive bacteria and EPS in biofilm. Glycosidic linkages in disaccharides and glycosides. Diversity of microbial life and the corresponding diversity in carbohydrate structures.

Functions of Carbohydrates: Energy storage and structural roles. Importance of carbohydrates in the microbial world: Structural components, energy reserves, signaling molecules, and ecological roles.

MODULE 2: LIPIDS AND NUCLEIC ACIDS **14Hrs**

Structure and Types of Lipids: Overview of lipids: Definition, classification (fatty acids, glycerolipids, phospholipids, sphingolipids, isoprenoids). Structure, nomenclature of simple lipids- free fatty acids (saturated, unsaturated), acyl glycerols and wax. Complex lipids (Triacylglycerols, phospholipids, sphingolipids). Sterols (cholesterol). **Functions of Lipids:** Energy storage, *membrane structure,* signaling molecules, and adaptation to diverse environments. Basic concepts of lipid chemistry: Hydrophobicity, amphipathicity, ester and ether linkages. Microbial lipids: LPS, Teichoic acids and Lipoteichoic acids, Mycolic acids, Archaeal ether lipids, Hopanoids.

Nucleic acid: Nucleoside, nucleotides and polynucleotides, DNA and RNA – types and structure. Specialized sequences -stem-loops, palindromic, denaturation and renaturation curves of nucleic acids

MODULE 3: AMINO ACIDS AND PROTEINS	**14Hrs**

Structure and Types of Amino Acids: Classification of amino acids (polar, nonpolar, acidic, basic). Peptide bond formation. **Protein Structure and Types:** Primary, secondary, tertiary, and quaternary structures. Fibrous and globular proteins. Ramachandran Plot. Protein folding. **Functions of Proteins:** Enzymes, structural proteins, and transport proteins. Protein functions relevant to microbial life.

Chirality in biological molecules: L- and D-amino acids.

Historical perspective on the discovery and early understanding of D-amino acids.

Occurrence and distribution of D-amino acids on microbes: The "D-amino acid world" hypothesis and its relevance to microbial evolution. The crucial role of D-alanine and D-glutamate in bacterial peptidoglycan structure and cross-linking, as regulators of bacterial biofilms, in quorum sensing and interspecies communication and in flagellar biosynthesis and function.

MODULE 4: ENZYMOLOGY	**14Hrs**

Enzymes: Definition, classification, nomenclature, specificity, active sites, coenzymes, activators and inhibitors, activity unit- Prosthetic groups, Coenzymes and cofactors. Factors influencing enzymatic activity. Ribozyme and abzyme.

Kinetics: Derivation of the Michaelis-Menten equation. Lineweaver-Burk plots. Enzyme inhibition (competitive, non-competitive, uncompetitive). **Enzyme Regulation:** Allosteric regulation, feedback inhibition. Covalent modification. **Enzyme assay and purification**: Enzyme assay, specific activity, enzyme isolation and purification. **Application of Enzymes in Biotechnology:** Industrial enzymes and their applications. Enzymes in diagnostics and research.

REFERENCES:

1. Brock Biology of Microorganisms by Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley, and David A. Stahl
2. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2005). *Lehninger principles of biochemistry*. Macmillan.
3. Microbiology: An Introduction by Gerard J. Tortora, Berdell R. Funke, and Christine L. Case.
4. Berg, J. M., Gatto Jr, G. J., Hines, J., Tymoczko, J. L., & Stryer, L. (2023). *Biochemistry*. Macmillan Higher Education.
5. Voet, D., & Voet, J. G. (2010). *Biochemistry*. John Wiley & Sons.
6. Moat, A. G., Foster, J. W., & Spector, M. P. (Eds.). (2002). *Microbial physiology*. John Wiley & Sons.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MMB5102**					
TITLE OF THE COURSE	**PROKARYOTIC MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To help students to understand about the importance of bacteria and viruses in our global society.
- Impart knowledge on the classification of bacteria and viruses along with their mode of nutrition and reproduction.
- To equip the safety measures in handling different types of microbes and to practice various methods used for isolation, cultivation, and identification of them from different sources and checking growth parameters at various conditions.
- To help students learn basic microbiological techniques employed for biochemical tests and quantitative analysis for checking the growth of prokaryotic microorganisms.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	The students will be acquainted with fundamental aspects of microbial diversity with respect to bacteria and viruses.	L1
CO2	Students will be able to understand knowledge on bacterial isolation, identification and classification.	L2
CO3	Students will learn about the importance of bacteria and viruses with respect to applications in varied fields as well disease-causing pathogens.	L3
CO4	Students will be equipped with fundamental knowledge of identification, growth patterns enabling them to apply in various allied fields.	L2

COURSE CONTENT:

MODULE 1: BACTERIOLOGY	**14Hrs**

Difference between prokaryotic and eukaryotic microorganisms. Ultrastructure of bacterial cell, Cell morphology: size, shape and arrangement; flagella, pili, capsule, cell wall, cell membrane, cytoplasm. nucleoid, plasmids, transposons. Endospores and exospores. Reproduction in bacteria. Intracytoplasmic inclusions: gas vacuoles, cellulosomes, carboxysomes, magnetosomes, parasporal crystals, metachromatic granules, polyhydroxybutyrate granules, glycogen, oil droplets, and sulphur globules. **Special forms of bacteria:** Actinobacteria, Cyanobacteria, Spirochetes, Rickettsia, Chlamydia, Archaebacteria and extremophiles.

MODULE 2: BACTERIAL GROWTH AND KINETICS	**14Hrs**

Nutritional uptake, nutritional factors required for growth and reproduction. Classification of microorganisms based on environmental and nutritional requirements. Cell division, Bacterial growth curve, Generation time; Growth Kinetics; Batch culture, Continuous culture - Chemostat and Turbidostatic. Synchronous culture, diauxic growth. Factors influencing the growth. Chemotaxis (signal transduction in microbes), quorum sensing, quorum quenching, biofilm formation, Phototaxis, magnetotaxis.

MODULE 3: VIROLOGY	**14Hrs**

Discovery, distinctive properties, morphology, Classification, Cultivation and Purification assay of virus. Type studies (Ultra-structure, replication and importance):
Animal virus: Retro viruses - HIV, Hepatitis, Pox virus, Picorna virus – Polio, Orthomyxovirus – Influenza- H1N1, SARS-CoV-2, Filoviridae - Ebola
Arbo virus - Dengue. Herpes and Adeno virus.
Plant viruses: TMV and CMV
Sub-viral agents: Satellite viruses, sat-RNAs, viroid, virusoids and prions. Application of viruses.

MODULE 4: BACTERIOPHAGES AND VIRAL ONCOLOGY	**14Hrs**

Bacteriophages - Ultra-structure and life cycle (lytic, lysogenic), Structural organization and Type studies (Ultra-structure, replication and importance): major RNA (MS2) and DNA (T4, lambda) bacteriophages. Application of bacteriophages.
Viruses and Cancer: Introduction to oncogenic viruses Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes. Application of Phage.

REFERENCES:

1. Brock Biology of Microorganisms 16th Edition (2020) Madigan MT, Martinko JM, Dunlap PV, Clark DP Prentice Hall publisher USA.
2. Foundations in Microbiology, (10th Edition) (2018) Kathleen Park Talaro and Barry Chess, Tata McGraw, India.
3. Microbiology, 10th Edition (2017) Lansing M Prescott, Donald A Klein, John P Harley, McGraw Hill publisher.
4. Understanding Microbes: An Introduction to a Small World Jeremy W. Dale (2012), Wiley-Blackwell.
5. Microbiology, 7th Edition (2009) Michael J Pelczar, Microbiology, Tata McGraw, India.
6. Virusphere: From Common Colds to Ebola Epidemics--Why We Need the Viruses That Plague Us (2020). 1st edition, Frank Ryan (Author), Publisher: Prometheus.
7. Guide to Clinical and Diagnostic Virology (2019), (ASM Books) 1st Edition, by ReetiKhare, Publisher: ASM Press.
8. Virology (2019), P. Saravanan. 5. Recent Advances in Animal Virology (2019) 1st Edition, Kindle Edition, by Yashpal Singh Malik, Raj Kumar Singh, Mahendra Pal Yadav, Publisher: Springer

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MMB5103**					
TITLE OF THE COURSE	**EUKARYOTIC MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To understand the structure, diversity, evolution, and functioning of eukaryotic microorganisms.
- To explore the roles of eukaryotes (fungi, algae, protozoa, and helminths) in ecology, industry, and human health.
- To study the molecular and cellular organization of eukaryotes.
- To comprehend the mechanisms of eukaryotic reproduction, genetics, and pathogenicity.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Demonstrate an in-depth understanding of the structure and function of eukaryotic cell organelles, their dynamics, and their role in cellular processes such as division and signalling.	L1
CO2	Analyse and interpret molecular mechanisms regulating gene expression, chromatin organization, and genetic recombination in eukaryotic microorganisms.	L2
CO3	Classify and explain the diversity, morphology, and life cycles of medically and industrially important fungi, protozoa, algae, and helminths.	L2
CO4	Evaluate the pathogenic mechanisms of eukaryotic microbes, host immune responses, and the applications of antifungal, antiparasitic agents, and industrially relevant eukaryotes.	L3

COURSE CONTENT:

MODULE 1: PHYCOLOGY **14Hrs**

Endosymbiotic origin of eukaryotes.

General characteristics of Algae, thallus organization, classification, ultra structure of cell, vegetative, asexual and sexual reproduction. Types of algae, ecological importance.

Algal life cycles- Haplontic, Diplontic, Diplohaplontic, Haplobiontic, and Diplobiontic type, Isolation from soil and water, Algal cultivation, measurement of algal growth. Structure and life cycle of Chlamydomonas, Spirogyra, Diatoms, Sargassum and Porphyra. Symbiotic algae: Lichens.

Economic importance of algae: Metabolic engineering of algae, Bioremediation, Biosensors, waste water treatment, algae as food and feed source. Production of bioactive compounds (Therapeutic compounds, antibiotics, Biofuel, Biopolymers, pigments, hydrogen production, biomaterials).

Pathogenic algae: Phytotoxins, Brief account on algal diseases – humans, animals and plants.

MODULE 2: MYCOLOGY	**14Hrs**
General characteristics of fungi, habitat, classification, distribution, nutritional requirements, Ecological significances. fungal cell ultra- structure, thallus organization and aggregation, fungal cell wall structure and synthesis, Sex and mating in fungi fungal spores – dormancy and dispersal. Sex hormones. Type studies: Aspergillus, Saccharomyces, Pythium, Rhizopus, Fusarium, Puccinia and Agaricus (Classification, Ultrastructure, reproduction, lifecycle, importance). Associations with plants (endophytes, mycorrhizal fungi), animals and humans. **Economic Importance:** Bioremediation, and production of secondary metabolites, bioactive compounds. Significance of yeasts and molds in health **Pathogenic fungi**: Mycotoxins, Fungal diseases – humans, animals and plants.	
MODULE 3: PROTOZOA	**14Hrs**
Protozoa: General features of Protozoa, diversity, classification, nutrition, excretion, locomotion, life cycles, reproduction, encystment, pathogenicity, and ecological roles of protozoan species. Cultivation of protozoa. Type study: Leishmania, Amoeba, Entamoeba and Plasmodium. Protozoan parasites of humans: Pathogenesis, symptoms, treatment, prevention of amoebiasis, malaria, Protozoa in veterinary importance: *Trypanosoma,* Protozoa as bioindicators in aquatic ecosystems, Symbiotic protozoa in termites and ruminants, Protozoa in nutrient cycling and food chains.	
MODULE 4: HELMINTHS, MICROSCOPIC ARTHROPODS, ADVANCED EUKARYOTIC MICROBIOLOGY	**14Hrs**
Helminths: Introduction, classification, general morphology, life cycle. Medically important Trematodes (Fasciola – liver fluke), Cestodes (Taenia solium), Nematodes (Filaria), Emerging and Re-emerging helminthic disease (Ascaris), diagnosis of helminths infections, Prevention, drug resistance, therapy. **Microscopic Arthropods:** General characteristics, habitat, feeding strategy of arthropods, classification Evolutionary significance and phylogenetic relationships, External morphology: segmentation, appendages, sensory organs, Internal anatomy: digestive, respiratory, nervous, circulatory, reproductive systems, Special adaptations in microscopic forms, Microscopy techniques for observing microscopic arthropods, importance in ecology, medical and agriculture. **Advanced eukaryotic microbiology:** General account on Yeast, Tardigrade, Slime mold as model organisms.	
REFERENCES:	
1. Brock Biology of Microorganisms 16th Edition (2020) Madigan MT, Martinko JM, Dunlap PV, Clark DP Prentice Hall publisher USA. 2. Foundations in Microbiology, (10th Edition) (2018) Kathleen Park Talaro and Barry Chess, Tata McGraw, India. 3. Microbiology, 10th Edition (2017) Lansing M Prescott, Donald A Klein, John P Harley, McGraw Hill publisher.	

4. Microbiology and Parasitology (2016) B. S. Nagoba, Elsevier Health Sciences.
5. Textbook of Microbiology (2016) R. Ananthanarayan, Orient Blacksman publications.
6. Textbook of Microbiology, (2013) Dubey RC, Maheswari DK S. Chand & Co.
7. Microbiology, 8th Edition International Student Version Jacquelyn G. Black (Marymount University) (2012), Wiley publication.
8. Understanding Microbes: An Introduction to a Small World Jeremy W. Dale (2012), Wiley-Blackwell.
9. Microbiology, 7th Edition (2009) Michael J Pelczar, Microbiology, Tata McGraw, India.
10. Advances in Applied Microbiology. (2007) Wayne W. Umbreit and D. Pearlman. Academic Press.
11. Evidence-Based Diagnosis: An Introduction to Clinical Epidemiology 2nd Edition, by Thomas B. Newman, Michael A. Kohn (2020).2 edition, Publisher: Cambridge University Press.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MMB5104**					
TITLE OF THE COURSE	**MICROBIAL TECHNIQUES: PRINCIPLES AND PRACTICES**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	**28**	**2**

COURSE OBJECTIVES:

- The course highlights on the practical and advanced techniques essential for microbial research and analysis.
- It covers media preparation, isolation, identification, growth, control, and preservation of microorganisms.
- Students will gain hands-on experience in various microscopy, staining techniques, and advanced analytical techniques like centrifugation and spectroscopy.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will learn to prepare media, isolate and identify diverse microorganisms, and analyze their growth kinetics.	L2
CO2	Students will be able to utilize various staining and microscopy techniques for visualizing microbial structures.	L1
CO3	Students will understand the relevance of spectroscopy and centrifugation techniques in microbial samples	L2

COURSE CONTENT:

MODULE 1: CULTURE MEDIA, GROWTH KINETICS AND CONTROL	**14Hrs**

Sterilisation and Disinfection- The rate of Microbial death. Physical (dry and moist heat, radiation, filtration) and chemical (alcohols, aldehydes, phenols, halogens, gases, heavy metals) methods of microbial control.

Microbiological Media: Simple media, complex media, synthetic or defined media, special media (enriched, transport media, selective, differential media, sugar media). Microbiological isolation techniques (serial dilution, pour plating, streak plating and spread plating).

Microbial characterization techniques: Biochemical characterization of bacteria, Phage typing, serological methods, molecular characterization.

Preservation of Microbial Cultures: Maintenance and preservation methods of microbial cultures. Methods for long-term storage of microbial cultures (lyophilisation, cryopreservation)**.**

Microbial Growth Measurement: Measurement of cell numbers- Counting chambers, viable counting techniques, Measurement of cell mass- dry weight and turbidity measurement.

MODULE 2: VISUALIZATION, MICROSCOPY AND ANALYTICAL TECHNIQUES	**14Hrs**

Staining Techniques: Dyes and Stains, Principles of staining, bacterial and fungal staining methods. Simple staining, differential staining, and Special staining. Light Microscopy**,** Bright-field, dark-field, phase-contrast, confocal and fluorescence, Atomic Force microscopy. **Electron Microscopy:** Scanning electron microscopy (SEM) and Transmission electron microscopy (TEM).

Centrifugation: Principles and applications of Differential, Rate-zonal Isopycnic (density gradient), Ultracentrifugation: analytical vs preparative, bench-top, High-speed, Continuous flow centrifuges. Types of rotors (Fixed-angle, Swinging-bucket, Vertical, Zonal). Application of centrifugation.

Spectroscopy: Principle and applications of UV-Visible, Fluorescence, Infrared (IR), Atomic Absorption Spectroscopy (AAS), Nuclear Magnetic Resonance (NMR) Spectroscopy.

REFERENCES:

1. Prescott's Microbiology (9th Edition) by Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton (2013) Publisher: McGraw-Hill.
2. Brock Biology of Microorganisms, 14th Edition, 2015. Publisher: Pearson
3. Vogel, A. I., (1989), Vogel's Textbook of Quantitative Chemical Analysis, 5th Edn., Longman.
4. Skoog, D. A., Holler, F. J., Crouch, S. R., (2014), Principles of Instrumental Analysis, 7th Edn., Cengage Learning.
5. Mendham, J., Denney, R. C., Barnes, J. D., Thomas, M., (2000), Vogel's Quantitative Chemical Analysis, 6th Edn., Pearson Education.
6. Sawhney, S. K., & Singh, R. (2001). Introductory Practical Biochemistry. Narosa Publishing House.
7. Plummer, D. T., (2004), An Introduction to Practical Biochemistry, 3rd Edn., Tata McGraw Hill.

8. Wilson, K., Walker, J., (2010), Principles and Techniques of Biochemistry and Molecular Biology, 7th Edn., Cambridge University Press.
9. Sadasivam, S., Manickam, A., (2008), Biochemical Methods, 3rd Edn., New Age International Publishers.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MSC5102**					
TITLE OF THE COURSE	**BIOSTATISTICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	**2**	**-**	**28**	**2**

COURSE OBJECTIVES:

- Build a strong foundation in statistical theory and methods with a focus on applications in health sciences, clinical research, epidemiology, and public health.
- Develop analytical skills to manage, analyse, and interpret biomedical data.
- Enable critical evaluation of scientific literature and the application of appropriate statistical methodologies in research design and analysis.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	To use statistical tools proficiently for data management, analysis, and reporting.	L2
CO2	Apply core statistical concepts and techniques in biological and health-related contexts.	L3
CO3	Interpret and communicate statistical results clearly in written and oral form, suitable for scientific publications and presentations.	L4

MODULE 1: MEASURES OF CENTRAL TENDENCIES, DISPERSION AND CORRELATION	**14 Hrs**

Introduction to Bio-statistics and its significance, use of replicates, Tabulation, and graphical representations of data. Different models of data presentations. Frequency distribution. Measures of Central tendency: Arithmetic mean, mode & median. Measures of variability: Range, mean deviation, and percentiles. Standard deviation and co-efficient of variation, Standard error Properties of the data: linear regression and correlation-test of significance, skewness and kurtosis and their various measures, Simple linear correlation and regression analysis. Analysis of variance. Sampling methods and their significance.

MODULE 2: PROBABILITY DISTRIBUTIONS AND TESTING OF HYPOTHESIS	**14 Hrs**

Probability: Definition, types of events, sample space, conditional probability, addition and multiplication rules of probability and some simple problems. Probability distributions- Binomial, Poisson and Normal distributions with simple numerical. Testing of hypothesis: basic concepts and definitions, types of errors, confidence intervals. Tests based on Normal, student's t, chi-square and F distributions, interpretation of "p" value. Anova- one way and two- way, Statistical package- Features of statistical software, SPSS for various applications in Biostatistical program.

REFERENCES:

1. Daniel. Biostatistics (3rd edition) Panima Publishing Corporation.
2. Khan. (5th Edition). Fundamentals of Biostatistics, Panima Publishing Corporation
3. Wardlaw, A.C. (1985). Practical Statistics for Experimental Biologists. Wiley-Blackwell.
4. Campbell, R.C. (2012) Statistics for Biologists, Cambridge Univ. Press, Cambridge

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MMB5171**					
TITLE OF THE COURSE	**TECHNIQUES IN ENZYMOLOGY AND BIOLOGICAL CHEMISTRY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	**6**	**-**		**3**

COURSE OBJECTIVES:

- This course will teach students fundamental biochemical techniques to quantify carbohydrates, DNA, and RNA in microbes, assay enzyme activity (including kinetics),
- To analyze microbial membrane lipids using extraction and thin-layer chromatography.
- To equip students with chemical estimations of various samples.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Upon completing this course, students will be able to quantify microbial carbohydrates, DNA, and RNA.	L4
CO2	Determine enzyme activity and kinetics (Km, Vmax) and perform lipid extraction and analysis using thin-layer chromatography.	L4
CO3	Students will be able to prepare buffers and determine pKa, pI and total hardness of samples	L4

PRACTICALS

1) Estimation of Carbohydrate
2) Estimation of DNA
3) Estimation of Protein
4) Estimation of enzyme activity – amylase
5) Enzyme kinetics-Km and Vmax of amylase
6) Lipid Extraction from Bacterial / Fungal Membranes
7) Thin-Layer Chromatography for Microbial Lipid Analysis
8) Preparations of buffers.
9) Determination of pKa of a weak acid by pH metric method.
10) Determination of Phosphorus in Aerated Drinks.
11) Determination of total hardness of water.
12) Determination of pI of amino acid (glycine).

REFERENCES:

1. Bisswanger, H. (2019). Practical enzymology. John Wiley & Sons.
2. Singh, R. (2000). Introductory practical biochemistry. Alpha Science Int'l Ltd.
3. Wilson, K., & Walker, J. (Eds.). (2000). Principles and techniques of practical biochemistry. Cambridge University Press.
4. Christie, W. W. (2014). Lipid analysis: isolation, separation, identification and structural analysis of lipids. Elsevier.
5. Harris, D. C. (2010). Quantitative chemical analysis. Macmillan.Wilson, K., & Walker, J. M. (Eds.). (2000). Practical biochemistry: principles and techniques. Cambridge University Press.
6. Vogel's Textbook of Quantitative Chemical Analysis 5th Edition (1989) A. I. Vogel, Longman, London, UK.

7. Principles of Instrumental Analysis 7th Edition (2014) Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Cengage Learning, Boston, USA.

8. Vogel's Quantitative Chemical Analysis 6th Edition (2000) J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, Pearson Education, London, UK.

9. Introductory Practical Biochemistry (2001) S. K. Sawhney, Randhir Singh, Narosa Publishing House, New Delhi, India.

10. An Introduction to Practical Biochemistry 3rd Edition (2004) D. T. Plummer, Tata McGraw Hill, New Delhi, India.

11. Principles and Techniques of Biochemistry and Molecular Biology 7th Edition (2010) Keith Wilson, John Walker, Cambridge University Press, Cambridge, UK.

12. Biochemical Methods 3rd Edition (2008) S. Sadasivam, A. Manickam, New Age International Publishers, New Delhi, India.

SEMESTER	**I**					
YEAR	**I**					
COURSE CODE	**25MMB5172**					
TITLE OF THE COURSE	**BASIC MICROBIOLOGICAL TECHNIQUES**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	**6**	**-**		**3**

COURSE OBJECTIVES:

- To introduce students to the fundamental isolation and culturing techniques of microbiology
- To equip students with practical skills for quantifying microbial populations and analyzing microbial growth
- To develop proficiency in using essential microbiological tools and methods for environmental sample analysis

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Demonstrate the preparation and application of various culture media for the growth and isolation of microorganisms.	L3
CO2	Isolate and identify microorganisms from diverse environmental sources	L3
CO3	Able to characterize microbial morphology and physiology.	L4
CO4	Quantify microbial populations and growth	L4

PRACTICALS

1) Preparation of culture media: Autotrophic, Heterotrophic, Selective, Enriched and Differential culture media
2) Isolation of Microorganisms from different sources (soil, water and air): Bacteria, Fungi and Algae
3) Pure culture techniques (Streaking, pour plate, spread plate, slant and stab culture) – 2 units
4) Simple staining, negative staining
5) Differential - Gram's and endospore
6) Fungal staining
7) Haemocytometer – enumeration of yeast cells and algae
8) Motility test by Hanging-drop method.
9) Isolation of bacteriophage from sewage water and plaque assay.
10) Measurement of microbial growth: Bacteria (turbidity)
11) Measurement of microbial growth: fungi (radial growth, biomass), algae(turbidity) – 2 units
12) Study of protozoa and microalgae permanent slides.

REFERENCES:

1. Maheshwari, D. K. (2002). *Practical Microbiology*. S. Chand Publishing.
2. Robert A Pommerville, Laboratory exercises in microbiology

3. Cappuccino and Sherman, Microbiology: A laboratory manual
4. Chandra, Fundamental Techniques in Microbiology

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMB5201**					
TITLE OF THE COURSE	**MICROBIAL PHYSIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- This course delves into the physiological processes of microorganisms, focusing on the factors influencing their growth and metabolism.
- Students will explore microbial diversity, the production and significance of bacterial and fungal secondary metabolites
- The students will be equipped with knowledge of the stress response of the adaptation by microbes under unfavorable conditions

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Upon successful completion of this course, students will be able to: Describe the structural components and functional roles of the cell envelope in bacteria, archaea, and eukaryotic microorganisms.	L1
CO2	Elucidate the fundamental principles of respiration (aerobic and anaerobic) and fermentation in microbial systems.	L2
CO3	Compare and contrast the metabolic diversity observed across different microbial species and their ecological significance.	L3
CO4	Analyze the mechanisms by which microorganisms develop resistance to stress factors and the role of secondary metabolites in stress tolerance.	L4

COURSE CONTENT:

MODULE 1: METABOLITE TRANSPORT AND BIOENERGETICS	**14Hrs**

Membrane Transport Mechanisms: Passive Transport: Simple diffusion, facilitated diffusion (channels and carriers). Active Transport: Primary active transport (ATP-binding cassette transporters, ion pumps), secondary active transport (symport and antiport), role of permeases in transport, Group translocation (phosphotransferase system in bacteria). Transport of amino acids and inorganic ions in microorganisms (Bacteria and fungi) and their mechanisms.

Bioenergetics: Principles of thermodynamics, Gibbs free energy, high energy compounds- ATP, NAD, FAD, FMN, quinones, components and mechanisms of respiratory chain.

MODULE 2: METABOLIC DIVERSITY OF MICROORGANISMS	**14Hrs**

Phototrophy (Photophosphorylation): Light-dependent reactions in prokaryotes (cyclic and non-cyclic photophosphorylation, reaction centers). Carotenoids and Phycobilins. Oxygenic and anoxygenic photosynthesis.

Chemolithotrophs: Inorganic compounds as Electron Donors, Hydrogen (H_2) oxidation, Oxidation of reduced sulphur compounds, Iron (Fe2+) oxidation, Nitrification and anammox.

Anaerobic respiration: Introduction. Nitrate, carbonate and sulfate as electron acceptors. Electron transport chains in some anaerobic bacteria.

Fermentation: Anaerobic Metabolism: Overview of fermentation: definition, purpose, and significance. Lactic and Mixed acid fermentations. Clostridial and propionate fermentations. Fermentation without substrate-level phosphorylation. Syntrophy.

MODULE 3: METABOLISM OF BIOMOLECULES	**14Hrs**

Carbohydrate Metabolism: Glycolysis: pathways, regulation, and energy yield. Pentose phosphate pathway (HMP Shunt), Entner Duodoroff's (ED) pathway, Gluconeogenesis. Glycogen metabolism. TCA cycle. Electron transport chain, generation and maintenance of PMF and inhibition of electron transport chain, oxidative phosphorylation. Structure of bacterial ATPase. Theories of ATP synthesis.

Lipid Metabolism: Lipid peroxidation (stress). Fatty acid biosynthesis.

Amino acid Metabolism: Overview of Amino acid degradation and biosynthesis. Transamination, decarboxylation.

Nucleic acid Metabolism: Overview of purine and pyrimidine biosynthesis (de novo) and salvage pathways. Nucleotide degradation and its role in cellular economy.

MODULE 4: SECONDARY METABOLITES AND STRESS PHYSIOLOGY	**14Hrs**

Bacterial and Fungal Secondary Metabolites: Definition and significance of secondary metabolites. Major bioactive compounds, Antibiotics: biosynthesis and mechanisms of action (brief overview). Toxins: types and their impact. Pigments: diversity and functions. Hormones: microbial production and roles.

Stress physiology: Osmotic stress and osmoregulation by glutamate and disaccharide trehalose, Osmotic control of Gene Expression. Aerobic to anaerobic transitions in facultative microbes (*E. coli*), Oxidative stress-SOD and catalase, Regulation of the Oxidative Stress Response, pH stress and acid tolerance, Thermal stress and heat shock response (genes), Nutrient stress and starvation stress, stringent control.

REFERENCES:

1. Microbial Physiology by Albert G. Moat and John W. Foster.
2. Brock Biology of Microorganisms by Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley, and David A. Stahl
3. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (2005). Lehninger principles of biochemistry. Macmillan.
4. Broome-Smith, J. K. (1999). Transport of molecules across microbial membranes (Vol. 58). Cambridge University Press.
5. Winkelmann, G. (Ed.). (2008). Microbial transport systems. John Wiley & Sons.
6. Singh, D. P. (2003). Stress physiology. New Age International.
7. Berg, J. M., Gatto Jr, G. J., Hines, J., Tymoczko, J. L., & Stryer, L. (2023). Biochemistry. Macmillan

Higher Education.
8. Gupta, V. G., & Pandey, A. (Eds.). (2019). New and future developments in Microbial Biotechnology and bioengineering: Microbial secondary metabolites biochemistry and applications. Elsevier.
9. Fouillaud, M., & Dufossé, L. (2022). Microbial secondary metabolism and biotechnology. Microorganisms, 10(1), 123.
10. Voet, D., & Voet, J. G. (2010). Biochemistry. John Wiley & Sons.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMB5202**					
TITLE OF THE COURSE	**MICROBIAL GENETICS AND MOLECULAR BIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To gain a thorough understanding of the basic principles of molecular biology and Microbial genetics.
- To understand the concepts of Bacteria, Phage & Yeast Genetics
- To understand the basic and advanced tools of DNA technology.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	The students will be able to learn the basics of microbial genetics and central dogma.	L1
CO2	Students will be able to understand the concepts of molecular mechanisms of replication, transcription and translation in microorganisms.	L2
CO3	Students will learn about the basic concepts and application of molecular genetics.	L1

COURSE CONTENT:

MODULE 1: ESSENTIALS OF MICROBIAL GENETICS **14Hrs**

Mendelian principles and extension of the principles in Neurospora and other Ascomycetes, Statistical tools used for study of genetics; genetic material in prokaryotes, eukaryotes and Viruses; DNA types and structures, C-value paradox, structure of chromatin and chromosomes, topology and supercoiling; knot and catenanes; DNA-protein interactions, Gene concept, interrupted genes, gene families, unique and repetitive DNA, transposons; genomic imprinting, linkage, crossing over, sex linkage, sex limited and sex influenced characters

Methods of genetic transfers in bacteria: Bacterial Transformation, Bacterial plasmids and Conjugation, Agrobacterium Genetics: Ti-plasmid, Restriction Modification (RM) systems, Types and process of Transduction; **Viral genetics:** T4 and Lambda Phages.

MODULE 2: FUNDAMENTAL MOLECULAR GENETICS **14Hrs**

Central Dogma, DNA Replication in prokaryotes, eukaryotes and viruses; enzymes involved and mechanism of replication, replication models, regulation of replication, role of telomerases, DNA synthesis and replication in retroviruses, extra-chromosomal replicons, inhibitors of replication,

Recombination signal, Mechanism of recombination, gene conversion, Mutation, Repair mechanism, Transposition, Microbial evolution, phylogenetics and speciation.
Gene regulation: Operon concept, phage strategies: Regulation of phages (T4 and Lambda), prokaryotic transcription regulation: regulation of lac and trp operons, eukaryotic transcription regulation: chromatin remodelling.

MODULE 3: TRANSCRIPTION AND TRANSLATION	**14Hrs**

Transcription: Organization of transcriptional units.
Prokaryotic and eukaryotic cells: Initiation, transcription, transcription factors, transcription activators and repressors, RNA polymerases, formation of initiation complex and its regulation, post transcriptional modifications, processing, transport; mRNA stability and localization.
Translation: Ribosomes, Initiation, elongation and termination; initiation factors and their regulation, elongation and elongation factors, translational proof reading, genetic code, post translational modification of proteins, translational inhibitors, role of tRNA, aminoacylation of tRNA.

MODULE 4: MOLECULAR GENETICS	**14Hrs**

Mapping genes by interrupted mating and molecular markers, Molecular Switch, Model Microbial strains and applications, virus as a genetic tool (M13 and lambda), plasmids regulation, genetic rearrangements and their evolutionary significance; Inheritance of Mitochondrial and chloroplast genes, somatic recombination, linkage and tetrad analysis.
Concepts of LUCA, Microbial genetic drift and shift, heritability and its measurements.

REFERENCES:

1. Lewin, B. (2008). Genes IX. London: Jones and Bartlett Publishers.
2. Watson, J. D. (1977). Molecular biology of the gene. Menlo Park, CA: Benjamin/Cummings.
3. Freifelder, D. (1985). Essentials of molecular biology.Jones and Bartlett Publishers.
4. Brown, T.A. (2010). Gene Cloning and DNA Analysis, An Introduction. 6th edition. (6th ed.) John Wiley & Sons Ltd
5. Glick, B.R., Pasternak, J.J. & Patten, C.L., (2022). Molecular Biotechnology: Principles and Applications of Recombinant DNA (6th ed.). ASM Press.
6. Maloy, S. R., Cronan, J. E., & Freifelder, D. M. (1994). Microbial genetics. Bartlett Publishers
7. Streips, U. N. & Yasbin, R. E. (2002). Modern microbial genetics. Wiley-Liss
8. Dale, J. W. and Park, S. (2004).Molecular genetics of bacteria. Wiley
9. Snyder, L., Peters, J.E., Henkin, T.M. & Champness, W. (2013) Molecular Genetics of Bacteria. ASM press
10. Hartl, D.L. & Jones, E. W. (1998). Genetics : principles and analysis. Jones and Bartlett Publishers

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMB5203**					
TITLE OF THE COURSE	**IMMUNOLOGY AND MEDICAL MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To help understand the mechanism of action of immune system, fundamental mechanism behind organ transplantation, autoimmune disorders and hypersensitive reactions.
- To help understand the students at an advanced level of microbial virulence mechanisms and host response to infection.
- To apply molecular techniques to medical microbiology; biochemical and genetic mechanisms of antimicrobial agent activity, microbial susceptibility and resistance to antimicrobial agents. Understanding principle and methodology of various immunological techniques.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be acquainted the essential structure, function, principles of antigens and antibodies and their types, various key concepts in immunology.	L1
CO2	Will be equipped to perform various immunological assays.	L2
CO3	Students will be acquainted with various infectious diseases and pathogenicity.	L3
CO4	Will be equipped with basic and molecular techniques in diagnostic laboratories, use of antibiotics and resistant mechanisms encoded in bacteria to neutralise these chemical agents.	L2

COURSE CONTENT:

MODULE 1: IMMUNE SYSTEM AND IMMUNE RESPONSES **14Hrs**

Innate, adaptive, humoral and cellular immunity. Primary and secondary immune responses. Structure and properties of antigens: Types of antigens, specificity, Haptens and adjuvants- structure and properties; Immunoglobulins: Structure and properties, types and subtypes. Immunoglobulin genes: organization and assembly. Major histocompatibility complex (MHC); structure and organization of MHC Class I and Class II molecules. T-cell receptor; B and T cell activation. Antigen processing, antigen presentation, Complement system – pathways, component, properties and functions. Immune response to cancer. Hypersensitivity reactions - types (I, II, III, and IV).

MODULE 2: AUTOIMMUNE DISORDERS, TRANSPLANTATION AND IMMUNOLOGICAL TECHNIQUES **14Hrs**

Autoimmune diseases- Insulin dependent Diabetic mellitus, Rheumatoid arthritis, Myasthenia gravis and their treatment. **Immunodeficiency Disorders:** SCID. **Tissue transplantation-** Graft versus host reaction and rejection, xenotransplantation.

Techniques- Immunoprecipitation; Agglutination; Complement fixation tests, Immuno-electrophoresis; Immunofluorescence; Cytotoxicity assay; flow cytometry; ELISA; RIA, Western blotting; ELISPOT; Tissue typing methods for tissue and organ transplantations.

MODULE 3: **PATHOGENIC DISEASES AND DIAGNOSIS**	**14Hrs**

Host Microbe Relationship- Normal microbial flora of human body and its significance. Koch's Postulates. Mode of entry of pathogen into human host. Infections and its types - nosocomial infections and non-infectious diseases. Immune response to infectious diseases; viral, bacterial, fungal and protozoal infections (Hepatitis, HIV, *Mycobacterium tuberculosis, Salmonella typhi, Candida albicans, Plasmodium vivax*).

Diagnostic Microbiology: Collection, transport and storage guidelines; biosafety in diagnostic laboratory and regulations. Biomedical waste management and treatment. Advances in molecular diagnosis: PCR and its clinical applications, Rapid antigen test, TrueNat, Feluda test based on CRISPR, CBNAAT.

MODULE 4: IMMUNOTHERAPY, VACCINATION AND ANTIMICROBIAL PROPHYLAXIS	**14Hrs**

Immunotherapy: Mucosal immunity (MALT, GALT, CALT), Polyclonal and monoclonal antibodies. Hybridomas and their production. **Vaccines**: Active and passive immunization, Immunization programs. Conventional vaccines, live vaccines, killed vaccines, toxoids, antisera, polysaccharide vaccines. Novel vaccines: RNA, subunit and peptide vaccines, DNA vaccines, recombinant vaccines, edible vaccines.

Antimicrobial Prophylaxis: Antibiotics, Classification of Antimicrobial agents, Mechanism of drug action-antibacterial, antiviral, antifungal and anti-protozoans. Mechanism of drug resistance and control measures.

REFERENCES:

1. Anathnarayana and Panikar (2013) Text Book of Microbiology, 9th Edition. University press.
2. Richard A, Goldsby, Thomas J, Kindt, Barbara A and Osborne (2000). Kuby Immunology. 4th Edition. W.H. Freeman and Company, New York.
3. Kuby J (2006) Immunology 6th Edition. W.H. Freeman and company, New York.
4. Warren Levinson (2000) Medical Microbiology and Immunology, Examination and Board Review. 8th Edition. McGraw Hill.
5. Tortora, Funke, Case (2009) Microbiology, 9th Edition. Benjamin Cummings.
6. Connie R Mahon (2010) Text book of diagnostic Microbiology. 3rd edition, Pearson.
7. Fritz H Kayser (2005) Medical microbiology. ThiemeVerlag.
8. Mackie and McCarthey (2006) Medical Microbiology vol 1, Microbial infection, vol 2, Practical Medical Microbiology, Churchil Livingstone.
9. Frank and Steven A (2002) Immunology and evolution of Infectious Diseases. Princeton

University Press.
10. Kufe (2003) Cancer Medicine. BC Decker Inc.
11. Jenson, Wright robinson (2007) Microbiology vol 1, Microbial Infection vol 2, Practical Medical Microbiology, Churchill living stone
12. Credric, A Mims (2004) Medical Microbiology, 3rd Edition. Mohshy Inc.
13. Nester Roberts Pearsall Anderson (2007) Microbiology- a human perspective, 2nd Edition, McGraw-Hill.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMB5204**					
TITLE OF THE COURSE	**ENVIRONMENTAL MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To make students understand the microbial ecology of various habitats (including terrestrial, aquatic, air and extreme habitats) and microbial community structure function
- To study interactions within a single microbial population and between two microbial populations and microbial interactions between animal and plant hosts
- To know the roles of microorganisms in biogeochemical cycles
- To understand the treatment of liquid and solid wastes and concepts of bioremediation

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the relationships between and role of microorganisms in ecological communities and role of microbes in maintenance of ecological balance.	L1
CO2	Students will have an overview of environment microbiological applications for sustainable treatment of water pollution and solid waste management.	L2
CO3	Students will understand microbiological standards of water potability and learn concepts of biodegradation of recalcitrant environmental pollutants.	L1

COURSE CONTENT:

MODULE 1: MICROBIAL ECOLOGY AND GEOMICROBIOLOGY **14Hrs**

Microbial ecology: Introduction to microbial ecology, significance of microbial biodiversity, Microbial interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation introduction to community structure in microorganisms, effect of sudden change in environmental factors on community structure, development of microbial communities, population selection within communities- r and k strategies, succession in microbial communities. Sessile and Planktonic communities. Conservation of microbial diversity.

Soil and Geomicrobiology: Soil: formation, as a Dynamic system, profile. Biotic and abiotic interactions; Habitat and niche; Soil erosion and soil conservation; Biogeochemical cycles - Carbon cycle, Nitrogen cycle and Sulphur cycle.

Diversity in anoxic eco system: Methanogens-reduction of carbon monoxide, reduction of iron, sulphur, manganese, nitrate and oxygen. Microbial transformations of Carbon, Phosphorus, Sulphur, Nitrogen and Mercury.

MODULE 2: AEROMICROBIOLOGY	**14Hrs**

Air microflora in different layers of atmosphere, bioaerosol; Microbiology of indoor and outdoor air; Significance of microorganisms in air; Enumeration of microorganisms in air (Impingement in liquids, Impingement in solids, suction and filtration); Control of air borne microorganisms. Molecular methods of air quality assessment; The Greenhouse effect, Ozone depletion, UV radiation and Acid rain. Aeroallergens and Allergies: Causes and tests for detection of aero allergens

MODULE 3: AQUATIC MICROBIOLOGY	**14Hrs**

Aquatic Microbiology: Natural waters, Microbial flora of aquatic environment, Zonation of water system, Upwelling; Marine microbiology: Hydrothermal vents, Nutrients in aquatic environments, Water pollution and water borne diseases, Eutrophication, Water purification, Ground water types and contamination; Water quality assays and public health (SPC, MPN, MFT, ONPG and MUG).

Sewage treatment: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment. Solid waste treatment (Landfills and Composting); Biogas production; Role of microbes in sewage treatment; Methanogens and methylotrophs. Newer approaches to sewage treatment and Enzyme technology for treating Industrial waste water.

MODULE 4: BIOLEACHING AND BIODEGRADATION	**14Hrs**

Bioleaching: Principles, microorganisms and microbe-mineral interactions. Bioleaching of copper, uranium and gold; Dump, heap and bioreactor operations. Role of acidophilic microorganisms in environmental pollution.

Biodegradation: Biodegradation of xenobiotic compounds and Recalcitrant compounds, Mechanism and enzymes involved in biodegradation. Role of plasmids in biodegradation. Biomagnification, Biodegradation of cellulose, lignin, hemicellulose, xylan, pectin, paper and plastic. Hazards from xenobiotics. '*in-situ'* remediation- Engineering developments - Constructed wet lands, Bioremediation of oils from contaminated soils; Bioremediation of heavy metals Phytoremediation and Mycoremediation. Microbial fuel cell, Microbial corrosion.

REFERENCES:

1. Prescott's Microbiology (9th Edition) by Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton (2013) Publisher: McGraw-Hill.
2. Maier RM, Pepper IL and Gerba CP. (2009). Environmental Microbiology. 2nd edition, Academic Press
3. Brock Biology of Microorganisms, 14th Edition, 2015. Publisher: Pearson
4. Microbiology Paperback by Michael Pelczar, E.C.S. Chain, Noel R. Kreig (2001). Publisher: McGraw Hill
5. Microbial Ecology: Fundamentals and Applications, Atlas and Bartha, Pearson Education.

6. Molecular Microbial Ecology: A Mark Osborn; Cindy J Smith, 2005, Taylor & Francis.
7. Environmental Microbiology: Raina M. Maier, Ian L. Pepper, Charles P. Gerba, 2000, Academic Press.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMB5205**					
TITLE OF THE COURSE	**AGRICULTURAL MICROBIOLOGY AND PLANT PATHOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To provide foundational knowledge of plant pathogens, their biology, ecology, and interactions with host plants.
- To develop skills in diagnosing plant diseases and understanding their epidemiology.
- To acquaint students with various disease management strategies, including cultural, biological, chemical, and integrated approaches.
- To understand positive interactions of microorganisms with plants including role of plant microbiota

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students must be able to explain the roles of beneficial and harmful microbes in agricultural systems	L1
CO2	They have to identify and describe symptoms, causal agents, and disease cycles of important plant diseases	L2
CO3	Have a substantial understanding about application of integrated disease management strategies for sustainable plant health	L3
CO4	Equipped with utilisation of diagnostic tools to detect and manage plant pathogens effectively	L3

COURSE CONTENT:

MODULE 1: FUNDAMENTALS OF AGRICULTURAL MICROBIOLOGY **14Hrs**

Soil microflora: Bacteria, fungi, actinomycetes, algae in soil, Rhizosphere and phyllosphere microbiology, Role of microbes in soil fertility. Soil humus. Soil testing-techniques and applications.

Nitrogen cycle: Nitrogen fixation (symbiotic, non-symbiotic), nitrification, denitrification, Transgenic plants (Nif gene), Plant Growth Promoters, Siderophores,

Biofertilizers: Types, application, quality control, cultivation and mass production of bioinoculants- Rhizobium, Azotobacter, Azospirillum, Cyanobacteria, Phosphate solubilizing microorganisms, Azolla, Mycorrhiza. Carrier-based inoculants–production, applications and limitations**.**

MODULE 2: PRINCIPLES OF PLANT PATHOLOGY	**14Hrs**
Definitions: Disease, pathogen, host, susceptibility, resistance, Classification of plant diseases: Infectious and non-infectious, Koch's postulates, Disease triangle and disease cycle, Mechanisms of pathogenesis: Entry, colonization, dissemination of pathogens. **Defence Mechanisms:** Pre-existing structural and chemical defences. Induced structural (histological-cork layer, abscission layer, tyloses, gums) and biochemical defences (hypersensitive response), systemic acquired resistance, phytoalexins, pathogenesis related (PR) proteins, plantibodies. **Major Plant Diseases:** **Fungal plant pathogens**: *Puccinia*, *Alternaria*, *Fusarium, Phytophthora.* **Bacterial plant pathogens**: *Xanthomonas*, *Pseudomonas.* **Viral plant diseases:** TMV, Banana bunchy top. **Nematode diseases:** Root-knot nematode, cyst nematode – symptoms and control **Algae:** red rust of tea. **Mycoplasma:** sandal spike. Case studies of economically important crop diseases (rice, wheat, vegetables, fruits).	
MODULE 3: DISEASE MANAGEMENT STRATEGIES	**14Hrs**
Principles of plant disease management, Methods: Cultural, chemical, biological, and integrated disease management (IDM) approaches, suppressive soil, Plant quarantine, Crop certification., Breeding for disease resistance. Post-harvest diseases and management, Disease epidemics, Disease forecasting, Plant clinic and plant doctor concept. Diagnosis of plant diseases, Role of molecular techniques in plant disease diagnostics, Farming education and awareness. **Biopesticides:** Types, mechanism and applications of different varieties. Biopesticides - *Pseudomonas fluroscence, Bacillus thuringiensis, Trichoderma harzianum, Trichoderma viridae*, Nuclear Polyhedrosis Virus and Baculovirus (Production, applications and limitations).	
MODULE 4: ADVANCED AGRICULTURE MICROBIOLOGY AND PLANT PATHOLOGY	**14Hrs**
Endophtyes concept and applications. Metagenomics in agricultural microbiology, molecular basis of symbiotic interactions: Rhizobium-legume, mycorrhizae, Microbial signaling molecules (quorum sensing, plant hormones), Recent advances in microbiome engineering for crop improvement, Nanotechnology and RNAi in plant disease control, Microbial consortia in sustainable agriculture. **GM Crops:** Golden rice, Bt Crops, Flavr Savr Tomato, Herbicide tolerant crop, significance in modern agriculture. Biosafety and regulations. Ethical, environmental and social concerns. Edible vaccines, Pharming.	
REFERENCES:	
1. Brock Biology of Microorganisms 16th Edition (2020) Madigan MT, Martinko JM, Dunlap PV, Clark DP Prentice Hall publisher USA. 2. Foundations in Microbiology, (10th Edition) (2018) Kathleen Park Talaro and Barry Chess, Tata McGraw, India. 3. Microbiology, 10th Edition (2017) Lansing M Prescott, Donald A Klein, John P Harley, McGraw Hill publisher.	

4. Microbiology and Parasitology (2016) B. S. Nagoba, Elsevier Health Sciences.
5. Textbook of Microbiology, (2013) Dubey RC, Maheswari DK S. Chand & Co.
6. Microbiology, 8th Edition International Student Version Jacquelyn G. Black (Marymount University) (2012), Wiley publication.
7. Understanding Microbes: An Introduction to a Small World Jeremy W. Dale (2012), Wiley-Blackwell.
8. Microbiology, 7th Edition (2009) Michael J Pelczar, Microbiology, Tata McGraw, India.
9. Advances in Applied Microbiology. (2007) Wayne W. Umbreit and D. Pearlman. Academic Press.
10. Virology (2019), P. Saravanan. 5. Recent Advances in Animal Virology (2019) 1st Edition, Kindle Edition, by Yashpal Singh Malik, Raj Kumar Singh, Mahendra Pal Yadav, Publisher: Springer.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMB5206**					
TITLE OF THE COURSE	**BIOINFORMATICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	**28**	**2**

COURSE OBJECTIVES:

- To make students understand the concept of bioinformatics
- To enable the students, learn various bioinformatics tools and techniques used in research

To provide students hand-on training on bioinformatics tools

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand bioinformatics and its importance.	L1
CO2	Perform scientific literature search and nucleotide and protein sequence analysis.	L2
CO3	Understand the methods and programs used for 3D structure analysis of proteins.	L1
CO4	Understand molecular phylogenetics and learn the use of DNA or protein sequences in developing evolutionary relationship.	L3

COURSE CONTENT:

MODULE 1: INTRODUCTION AND TOOLS IN BIOINFORMATICS	**14Hrs**

Fundamental of bioinformatics-goals, scope, applications and limitations, introduction to biological database (primary, secondary and specialized databases), scoring matrices, extraction of knowledge from resources, Human genome project, Data-mining, Sequence analysis and Structure display tools, Homology/ Similarity search tools, transcription and translation tools.

MODULE 2: STRUCTURAL BIOINFORMATICS	**14Hrs**

Structural bioinformatics and Molecular Phylogenetics

Protein 3D structure evaluation, visualization, comparison and classification, Introduction to alignment and molecular phylogenetics, tree topologies, methods and in brief about programs of tree constructions and evaluation, overview of homology modelling molecular docking

Bioinformatics tools training through class activity

Data base searching, Restriction site analysis, primer designing, sequence alignment (BLAST, Clustal Omega), molecular graphics visualization (RasMol).

REFERENCES:

1. Xiong, J., 2006. *Essential bioinformatics*. Cambridge University Press.
2. Jeremy Ramsden (2015) Bioinformatics: An Introduction, Third Edition. Springer.
3. Jacques Izard, Maria C. Rivera (2015) Metagenomics for Microbiology. Elsevier.
4. D. Barcello (2014) Fundamentals of Advanced Omics Technologies: From Genes to Metabolites (Comprehensive Analytical Chemistry Volume) Elsevier B.V.
5. Edward F. Delong (2013) Microbial Metagenomics, Metatranscriptomics, and Metaproteomics (Methods in Enzymology Vol.) Elsevier Inc.
6. Encyclopedia of Genetics, Genomics, Proteomics and Bioinformatics. John Wiley & Sons.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMB5271**					
TITLE OF THE COURSE	**TECHNIQUES IN MICROBIAL PHYSIOLOGY, IMMUNOLOGY AND MEDICAL MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	**6**	**-**		**3**

COURSE OBJECTIVES:

- This lab aims to train students in biochemical tests for microbial characterization, enzyme screening assays, protein quantification.
- The students will gain practical skill on SDS-PAGE analysis of membrane proteins, small-scale secondary metabolite extraction, and antibiotic susceptibility testing.
- To apply molecular techniques to medical microbiology; biochemical and genetic mechanisms of antimicrobial agent activity, microbial susceptibility and resistance to antimicrobial agents

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Upon completion, students will be able to perform and interpret biochemical tests, enzyme assays, protein estimation.	L4
CO2	To introduce basic and molecular techniques employed in diagnostic bacteriology laboratories.	L1
CO3	Students will be able to perform SDS-PAGE of membrane proteins, secondary metabolite extraction, and antibiotic susceptibility testing.	L4

PRACTICALS:

1) Biochemical test: Catalase, Oxidase, Hydrogen sulfide production in TSIA
2) Indole, Methyl Red, Voges-Proskauer, Citrate Utilization Test
3) Plate assays for enzyme screening: Starch, Casein and Gelatin hydrolysis
4) Small-Scale Solvent Extraction of Secondary Metabolites from culture broth and biomass
5) Isolation and identification of microflora from throat, skin, sputum, nasal sample
6) Dental caries susceptibility assay by Snyder's agar test
7) Assay for susceptibility and resistance of antibiotics by Kirby Bauer method
8) Identification of different types of White blood cells
9) Serological tests: Agglutination - Blood grouping and Rh typing
10) Indirect Agglutination test- WIDAL / VDRL
11) Precipitation reactions: Ouchterlony Double Diffusion
12) Radial Immuno Diffusion
13) DOT ELISA
14) Isolation of lymphocytes from peripheral blood

REFERENCES:

1. Maheshwari, D. K. (2002). Practical Microbiology. S. Chand Publishing.
2. Wilson, K., & Walker, J. M. (Eds.). (2000). Practical biochemistry: principles and techniques. Cambridge University Press.
3. Sambrook, J., & Russell, D. W. (2006). The condensed protocols from molecular cloning: a laboratory manual. Cold Spring Harbor Laboratory Press.
4. Kuby J (2006) Immunology 6th Edition. W.H. Freeman and company, New York.
5. Mackie and McCarthey (2096) Medical Microbiology vol 1, Microbial infection, vol 2, Practical Medical Microbiology, Churchil Livingstone.
6. Frank and Steven A (2002) Immunology and evolution of Infectious Diseases. Princeton University Press.
7. Wadher and Bhoosreddy (2005) Manual of Diagnostic Microbiology. Himalaya Publisher.
8. Jenson, Wright robinson (2007) Microbiology vol 1, Microbial Infection vol 2, Practical Medical Microbiology, Churchill living stone.

SEMESTER	**II**					
YEAR	**I**					
COURSE CODE	**25MMB5272**					
TITLE OF THE COURSE	**TECHNIQUES IN AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	**6**	**-**		**3**

COURSE OBJECTIVES:

- The course will help in making the students learn techniques to study microbial interactions and their impact in nature.
- The course imparts practical knowledge in screening the microorganisms for their employment in various fields
- To expose students to various roles of microorganisms in nature

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	To impart hands-on skills in isolating agriculturally important microorganisms such as nitrogen fixers and phosphate solubilizers, and to study their role in plant health and soil fertility.	L4
CO2	To develop the ability to analyze plant physiological responses to disease by estimating key biochemical markers such as phenols and chlorophyll content.	L4
CO3	Students have fundamental practical knowledge of the techniques to study microbial interactions and their role in environment.	L3
CO4	Students will learn many techniques to study the impact of microorganisms in different applied microbiological studies.	L3

PRACTICALS

1) Sampling and isolation of bacteria from plant rhizosphere and phyllosphere.
2) Microbial interaction assay using well and cross-streak assay.
3) Degradation of natural recalcitrant (Pectin, Cellulose) and hydrocarbons on plate/Winogradsky column.
4) Effect of seed borne fungi on seed germination and seed vigour.
5) Determination of Total solids, Dissolved Oxygen
6) Determination of Biological Oxygen Demand (BOD)
7) Determination of Chemical Oxygen Demand (COD)
8) Isolation of symbiotic and non-symbiotic nitrogen fixing microorganisms.
9) Estimation of total phenols in diseased and healthy plant tissues.
10) Estimation of chlorophyll in diseased and healthy plant tissue.

REFERENCES:

1. Aneja, K. R. (2017). Experiments in Microbiology, Plant Pathology and Biotechnology (5th ed.). New Delhi: New Age International Publishers.
2. Dubey, R. C., & Maheshwari, D. K. (2016). Practical Microbiology. New Delhi: S. Chand & Company Ltd.
3. Cappuccino, J. G., & Sherman, N. (2014). Microbiology: A Laboratory Manual (10th ed.). Boston: Pearson Education.
4. Sharma, K. (2015). Manual of Microbiology. New Delhi: Ane Books Pvt. Ltd.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMB5301**					
TITLE OF THE COURSE	**GENETIC ENGINEERING AND rDNA TECHNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- This course explores the theoretical concepts and methodologies involved in recombinant DNA (rDNA) technology, with a focus on microbial applications.
- Topics include the principles of genetic manipulation in microorganisms, cloning vectors, gene expression systems, and the use of recombinant microorganisms in biotechnology.
- Case studies will highlight the role of rDNA technology in medicine, agriculture, and industrial applications.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to understand the fundamental principles of recombinant DNA technology and describe the process of genetic manipulation in microorganisms.	L1
CO2	Students will be able to evaluate the use of various cloning vectors and gene expression systems and analyse the applications of microbial rDNA technology in biotechnology.	L2
CO3	Students will be able to discuss ethical, safety, and regulatory considerations in genetic engineering.	L1

COURSE CONTENT:

MODULE 1: rDNA TECHNOLOGY	**14 Hrs**

History and development of rDNA technology. Overview of key concepts: DNA manipulation, cloning, and transformation. Structure and function of nucleic acids. Applications of rDNA technology in microbiology, medicine, and industry. Gene expression and regulation in microorganisms (operons, regulatory elements, repressors, activators). Overview of transcription and translation mechanisms in prokaryotes. Factors influencing gene expression.

MODULE 2: DNA FRAGMENTATION AND CLONING	**14 Hrs**

Methods for DNA extraction from microbial cells, Purification and quantification of DNA, Polymerase Chain Reaction and its Applications, Agarose gel electrophoresis and DNA visualization techniques. Discovery and function of restriction enzymes, Types of restriction enzymes and their applications. DNA digestion, ligation, and fragment analysis. **Cloning Vectors:** Types and Applications (Plasmids, Bacteriophages, Cosmids, Phagemids). Gene Cloning (isolation of gene of interest, insertion into vector) and Transformation (recombinant vector, replication and cloning). Applications of gene cloning. Gene Expression Systems in Microorganisms (constitutive and inducive).

MODULE 3: PROTEIN EXPRESSION AND GENE EDITING	**14 Hrs**

Protein expression and purification techniques. **Site-Directed Mutagenesis and Gene Editing:** Introduction to mutagenesis techniques, Principles of site-directed mutagenesis, Applications of CRISPR/Cas9 in microbial genetics. **Microbial Genomic Libraries:** Construction of genomic libraries, Screening techniques for isolating specific genes, Applications in functional genomics and drug discovery.

MODULE 4: GENE KNOCKOUT AND KNOCK IN TECHNIQUES	**14 Hrs**

Principles of gene knockout in microorganisms. Methods: Homologous recombination, CRISPR/Cas9. Applications in studying gene function and microbial pathogenesis. **Applications of Microbial rDNA Technology in Biotechnology:** Recombinant microorganisms in the production of therapeutic proteins (insulin, vaccines). Genetically modified microorganisms for crop protection. **Advanced Topics in rDNA Technology:** Synthetic biology and the future of microbial engineering. Designer microorganisms and their potential applications. Personalized medicine and microbial gene therapy.

REFERENCES:

1. Sambrook, J., & Russell, D. W. (2012). Molecular Cloning: A Laboratory Manual (4th ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics (7th ed.). Malden, MA: Blackwell Publishing.
3. Watson, J. D., Myers, R. M., Caudy, A. A., & Witkowski, J. A. (2007). Recombinant DNA: Genes and Genomes – A Short Course (3rd ed.). New York, NY: W. H. Freeman and Company.
4. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). Molecular Biology of the Gene (7th ed.). Boston, MA: Pearson Education.
5. Dhanasekaran, M. S., & Narasimhan, M. A. R. G. (2016). Microbial Biotechnology: Applications in Agricultural and Environmental Sustainability. New Delhi: Springer India.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMB5302**					
TITLE OF THE COURSE	**INDUSTRIAL, FOOD AND DAIRY MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	4	**0**	**-**	**-**	**56**	**4**

COURSE OBJECTIVES:

- To exhibit depth of knowledge by demonstrating microbial sciences in the field of applied fields of industrial, food and dairy microbiology.
- To relate microbes in interdisciplinary connections with other sciences, in particular to industrial productions, food sciences and dairy products.
- To encode the importance of the role of microorganisms in food and dairy industries both in beneficial and harmful ways.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	It will develop depth understanding on fermentation technology, modern microbial techniques and analysis relating to industrial, food and dairy microbiology.	L1
CO2	Help evaluate microbial application with current analysis techniques relating to productions, food sciences and dairy products.	L2
CO3	Determine food, milk quality by food analysis as per food safety standard law and their importance in food industry.	L3
CO4	Will help student learn different metabolite productions to imply in industrial aspects.	L2

COURSE CONTENT:

MODULE 1: INDUSTRIAL MICROBIOLOGY **14Hrs**

Concepts and scope of microbes in industry. Screening, isolation of industrially important microbes. Strain improvement- mutation, recombination- gene regulation and genetic manipulation. Preservation of industrially important microbes. Culture collection centers.

Basic components and design of typical fermenter. Types of fermenters- Laboratory, pilot- scale and production fermenters; stirred tank fermenter, tower fermenter, fluidized bed bioreactors and air-lift fermenter. Types of fermentation process - Batch, chemostat, submerged and solid-state fermentation. Different parameters affecting fermentation. Basics of optimizing parameters.

MODULE 2: INDUSTRIAL BIOPROCESSING **14Hrs**

Upstream Processing: Substrates/raw materials used in fermentation medium (molasses, corn steep liquor, whey, hops), Nutrients: growth factors, carbon, nitrogen, mineral sources. Buffers, inhibitors, precursors, inducers, oxygen requirements, antifoam agents. Methods of media and air sterilization, Inoculum preparation and inoculum development. **Downstream processing:** Solid matter, Foam separation, Precipitation, Filtration, Centrifugation, Cell disruption, Liquid extraction, Solvent recovery, chromatography, Drying, Crystallization, Whole broth processing.

Productions and Applications: Alcohol production, organic acids (citric acid), enzymes: amylases-(Fungal and Bacterial). Amino acid - L-Glutamic acid. Vaccines (Hepatitis B), hormones (human insulin), antibiotic (Penicillin). Applications of genetic engineering in industrial bioprocessing. Concept of Patenting law, Copyrights, and Trademarks. Patent regulations and filing, processes, products and microorganisms.

MODULE 3: FOOD MICROBIOLOGY	**14Hrs**

Scope and Development of food microbiology. Food as a substrate for microorganisms; Principles and methods of food preservation: Physical and Chemical. Bio-preservation. Food Additives, Microbial spoilage of food: Causes and sources of food spoilage. Food borne Infections and Intoxications: *Clostridium, Hepatitis A*, Mycotoxins (Aflatoxins, Ochratoxins,).

Fermented foods: Fermented Vegetables (Pickle, Sauerkraut), Tempeh, Alcoholic beverages, Kombucha, Sausages, Bread and Idli. Nutritional and therapeutic importance: Mushrooms, Single cell Protein, Quorn. Nutraceuticals. Food control Agencies: HACCP, Employees Health standards, GMP.

MODULE 4: DAIRY MICROBIOLOGY	**14Hrs**

Nutritional level and microbial flora of milk. Sterilization of milk; predominant types of microorganisms in chilled and refrigerated milk and their importance; heat resistant bacteria and their role in milk spoilage; Principles of quality control tests for milk; bacteriological grading.
Production and Microbiology of dairy products: cream, butter, yogurt, acidophilus milk, curd, kefir, koumiss, shrikhand, cultured butter milk, Cheese: production and types. Prebiotic, Probiotics, Postbiotics and Synbiotics. Biosensors in Food Industry, genetically modified foods, Food fortification.

REFERENCES:

1. Casida L.E.J.R (2015) Industrial Microbiology, New Age International, New Delhi.
2. Stanbury PF, Whitakar A and Hall SJ (2009) Principles of Fermentation Technology, 2nd Edition Aditya Books (P) Ltd, New Delhi.
3. McNeil B and Harvey LM. Fermentation. A Practical Approach, IRL press, New York.
4. Robert H (2006) Microbiology and Technology of Fermented Foods. Blackwell Publishers.
5. Matthew Rimmer (2008) Intellectual Property and Biotechnology: Biological Inventions Edward Elgar. Betty C. Hobbs, Food Microbiology, Arnold-Heinemann Publishing Private Limited, New Delhi.
6. Frazier and Wasthoff, Food Microbiology, Tata McGraw-Hill Publishing Company Limited, New Delhi
7. Hammer B.W and Babal, Dairy Bacteriology, Prentice Hall Incorporated, London.

8. James M.J. Modern Food Microbiology, CBS Publishers and Distributers, Delhi. 2006
9. Mary E.T and Richard E. I. Microbial Food Safety Animal Agriculture: Current Topics, Iowa state University Press. 2003
10. Bibek R. Fundamentals of Food Microbiology. Bibek Ray. 2nd Edition. CRC press. 2001.
11. Adams M.R. and Moss M.O. Food Microbiology. Royal Publishing Corporation. 2000.
12. John G. Essentials of Food Microbiology. Arnold International Students Edition.
13. Frazer W.C. Food Microbiology. McGraw Hill, New York. 2009.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**20MMB5303**					
TITLE OF THE COURSE	**ADVANCED MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

- To help understand the students about the importance of bacteria and viruses in our global society.
- To equip the safety measures in handling different types of microbes and to practice various methods used for isolation, cultivation, and identification of them from different sources and checking growth parameters at various conditions
- To help students learn basic microbiological techniques employed for biochemical tests and quantitative analysis for checking the growth of prokaryotic microorganisms.

To become proficient with a number of advanced and basic tools.

COURSE OUTCOMES:

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	The students will be acquainted with fundamental aspects of microbial diversity with respect to bacteria and viruses.	L1
CO2	Students will be able to understand the to understand their diversity with structural organization, functions, habitat etc.	L2
CO3	Students will learn about the importance of bacteria and viruses with respect to applications in varied fields as well disease-causing pathogens.	L3
CO4	Students will be equipped with fundamental knowledge of identification, growth patterns enabling them to apply in various allied fields.	L2

COURSE CONTENT:

MODULE 1: MICROBIOME **14Hrs**

Microbiome perspective, environmental genomics, microbiomes of oceans and terrestrial ecosystems. Approaches in Microbiome analysis, Metagenomics (open and closed formats), Meta- transcriptomics, Pan-genomics, Epigenomics, Microfluidics technology in human microbiome, single cell genomics. Metagenomics of archaeological samples, Sargasso Sea project.

Human microbiome: biodiversity and major genera of human-microbiome, human- microbiome system as a "holobiont" or "superorganism. Microbiome distributions in healthy individuals; composition of specific body sites 'microbiome: skin, oral.

Microbiome and disease biology: gut-brain conversation, microbiome's role in diseases, gut microbiome on infectious and non-infectious diseases (Inflammatory bowel disease (IBD) and obesity). Effects of diet on microbiome. Personnel microbiome concepts. Designer probiotics. Dysbiosis -Rebiosis, FMT.

MODULE 2: EXTREMOPHILES AND EXOMICROBIOLOGY	**14Hrs**

Extreme Habitats. Classification and salient features of archaea. Microbial classification and adaptations for thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, radiation, oxygen concentration and low nutrient levels. Extremophiles - bacteria, archaea and eukaryotes. Genetic and Metabolic diversity of extremophiles. Applications of extremophiles.

Exomicrobiology: Space environment, Life detection methods: (a) Evidence of metabolism (Gulliver) (b) Evidence of photosynthesis (autotrophic and heterotrophic) (c) ATP production (d) Phosphate uptake (e) Sulphur uptake, Simulation techniques, Role of gravity, Microgravity and effect on microorganisms. Panspermia and its types. Microbes in spacecraft environment, Pathogenesis, virulence, biofilm formation. Spacecraft sterilisation. Astronauts' microbial flora and food. Microbial food safety in space production systems.

MODULE 3: MICROBIAL NANOTECHNOLOGY	**14Hrs**

Classification of Nanostructures as 1D, 2D and 3D nanomaterials. Classification of NPs: Organic, inorganic and biological sources. Nano-materials in biological systems: Proteins, Lipids, RNA and DNA. Protein Targeting – micro/nanomaterial - Protein Interactions Nanomaterial-Cell Interactions Manifestations of Surface Modification (Polyvalency). Microbial synthesis of Nanoparticles. Characterization of nanoparticles: UV-Vis spectroscopy, Electron Microscopy – HRTEM, SEM, AFM, EDS, XRD. Biomedical applications in diagnostics, delivery and therapeutics, nano toxicology: Cytotoxicity, Gen-toxicity In vivo tests/assays etc. Applications of microbial NPs in agriculture, food, environmental and other sectors.

REFERENCES:

1. Marchesi, J. R. (2016). Human Microbiome: An Introduction to Microbes in Health and Disease. London: Academic Press.
2. Nagarajan, M. (2018). Metagenomics: Techniques, Applications, Challenges and Opportunities. Boca Raton, FL: CRC Press.
3. Tungland, B. (2018). Microbiome in Human Health and Disease. London: Academic Press.
4. Pepper, I. L., & Gerba, C. P. (2014). Environmental Microbiology (3rd ed.). Amsterdam: Elsevier.
5. Das, S., & Dash, H. R. (Eds.). (2018). Microbial Ecology and Extremophiles. Singapore: Springer.
6. Sharma, P., & Patil, R. V. (2023). Archaea and Extremophiles: From Origin to Applications. Singapore: Springer Nature India.
7. Nathani, N. M., & Pandey, A. (2022). Microbial Nanotechnology: Green Chemistry for Sustainable Development. London: Academic Press.
8. Chattopadhyay, K. K., & Banerjee, A. N. (2012). Introduction to Nanoscience and Nanotechnology. New Delhi: PHI Learning Pvt. Ltd.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMB5304**					
TITLE OF THE COURSE	**TRANSLATIONAL MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

- To introduce concepts of entrepreneurship and business development in microbiology-related sectors
- To explore applications of Artificial Intelligence (AI) and Machine Learning (ML) in microbiological research and industries
- To equip students with knowledge of bio-entrepreneurial strategies and computational tools
- To provide students with a comprehensive understanding of synthetic biology principles and microfluidic technologies, enabling them to design genetic circuits, perform genome editing, and apply lab-on-a-chip platforms in microbiological and biotechnological research.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Understand the principles of entrepreneurship, innovation, and business development specific to microbiology-based industries.	L1
CO2	Analyze market opportunities and develop business models for microbial products and technologies.	L3
CO3	Explain the fundamentals of AI and Machine Learning and their relevance in microbiological research and applications.	L2
CO4	Apply AI/ML tools to analyze microbiological datasets for genomics, antimicrobial resistance, microbiome analysis, and pathogen detection.	L3
CO5	Students will be able to demonstrate the application of microfluidic systems for high-throughput microbial analysis and diagnostic purposes	L4

COURSE CONTENT:

MODULE 1: AI AND ML IN MICROBIOLOGY **14Hrs**

Basics of AI, ML, and their relevance in microbiology, Types of machine learning: supervised, unsupervised, reinforcement learning, Applications of AI/ML in Microbiology: AI/ML for microbial genome analysis, annotation, and metabolic pathway prediction, Predictive modeling of antimicrobial resistance, AI in drug discovery, microbiome analysis, and synthetic biology, ML tools for rapid pathogen detection and epidemiological modelling, Biopython. Introduction to data preprocessing, feature selection, model evaluation, Ethics and challenges in AI/ML applications in biological sciences.

MODULE 2: SYNTHETIC BIOLOGY AND MICROFLUIDICS	14Hrs
Synthetic pathway design, Artificial photosynthesis, Genome synthesis and editing. Genetic circuit design, Metabolic engineering principles. Recent Advancements: Large-Scale DNA Assembly, CRISPR-Cas Technologies, Synthetic Genetic Circuits, Biosensor-Based Therapeutics, AI Integration. Introduction to Microfluidics: Basics of microfluidic systems. Microfabrication Techniques: Photolithography and soft lithography. Materials used in microfluidic devices. Microfluidic Components: Micropumps, micromixers, and microvalves, Lab-on-a-chip devices. Applications: Microfluidic cell culture, On-chip genetic analysis, Organ-on-a-chip systems.	
MODULE 3: BIOENTREPRENEURSHIP	**14Hrs**
Principles of entrepreneurship and innovation, Startups and business models in Microbiology, Market analysis and opportunity identification in microbial products (antibiotics, enzymes, biofertilizers, biopesticides, probiotics), Case studies of successful microbiology-based startups. Business Development and Regulatory Landscape, Intellectual Property Rights (IPR), patents, trademarks in Microbiology, Licensing and technology transfer in microbiological innovations, Regulatory frameworks: IBSC, RCGM, GEAC, FDA, FSSAI, EPA, BIS (relevant to microbial products), Business plan writing and pitching for microbiology ventures Hands on training in Microbiology based bioentrepreneurs.	

REFERENCES:

1. Khanka, S. S. (2006). Entrepreneurship Development. New Delhi: S. Chand & Company Ltd.
2. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Academic Press.
3. Grossman, M. R. (2003). Entrepreneurship in Biotechnology: Managing for Growth from Start-Up. Westport, CT: Praeger Publishers.
4. Finlay, S. (2018). Artificial Intelligence and Machine Learning for Business: A No-Nonsense Guide. London: Relativistic.
5. Zhang, Y.-Q. (2007). Machine Learning in Bioinformatics. Boca Raton, FL: CRC Press.
6. Baxevanis, A. D., & Ouellette, B. F. F. (Eds.). (2005). Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (3rd ed.). Hoboken, NJ: Wiley-Interscience.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMB5305**					
TITLE OF THE COURSE	**ADVANCED MICROBIOLOGICAL TECHNIQUES**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

- To provide students with in-depth theoretical knowledge in advanced microbiological techniques.
- To analyse the application of microorganisms in modern molecular, biochemical, and imaging techniques.
- To apply the knowledge in microbial research, diagnostics, and biotechnology, while also emphasizing biosafety, quality control and data interpretation.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Learn advanced microscopic and molecular tools for the identification and characterization of microorganisms and study microbial physiology, genetics and interactions.	L1
CO2	Understand the utilization of advanced imaging, cell sorting techniques such as fluorescence microscopy and flow cytometry.	L2
CO3	Understand quantitative and qualitative analysis of microbial communities using culture-dependent and culture-independent methods (e.g., PCR, qPCR, metagenomics).	L3

COURSE CONTENT:

MODULE 1 CHROMATOGRAPHY, SEPARATION SYSTEMS AND NGS	**14 Hrs**

Limitations of basic techniques, Need for advanced tools in research and diagnostics, Classification of advanced techniques. **Automated Microbial Identification Systems:** MALDI-TOF MS (Matrix-Assisted Laser Desorption/Ionization-Time of Flight), VITEK and BACTEC systems, Advantages and limitations. **Flow Cytometry in Microbial Analysis:** Principle of flow cytometry, Applications: Cell counting, viability, sorting, use in studying microbial physiology.

Advanced Microscopy Techniques: Confocal Laser Scanning Microscopy, Electron Microscopy (SEM and TEM), Fluorescence and live-cell imaging.

Microbial Genomics and Metagenomics: Next-Generation Sequencing (NGS) basics, Whole-genome sequencing of microbes, Metagenomic approaches to uncultivable microbes.

MODULE 2: MOLECULAR DIAGNOSTICS, PROTEOMICS AND GENOME EDITING	**14 Hrs**

Molecular Diagnostic Techniques: Real-time PCR (qPCR), Digital PCR, Loop-mediated isothermal amplification (LAMP), Applications in pathogen detection. **Transcriptomics and Gene Expression**

Analysis: RNA extraction and quality control, RT-PCR and microarray principles, Applications in stress response and pathogenesis.

Proteomics and Protein Profiling: 2D-PAGE, mass spectrometry, and protein fingerprinting, Proteomic applications in microbial classification and function.

CRISPR-Cas and Genome Editing in Microbiology: Basics of CRISPR-Cas mechanism, Gene knockouts and functional studies in microbes, Applications in synthetic biology.

MODULE 3: BIOSENSORS, BIO-IMAGING AND HIGH THROUGHPUT TECHNOLOGIES	**14 Hrs**

Biosensors and Biochips in Microbial Detection: Types of biosensors: Electrochemical, optical, DNA-based, Microarrays and lab-on-a-chip systems, Field applications in environmental and clinical microbiology.

Microbial Imaging and Spectroscopy Techniques: FTIR and Raman spectroscopy in microbial studies, Atomic Force Microscopy (AFM), Imaging applications in biofilms and microbial surfaces.

High-throughput Screening and Microarrays: Techniques for screening microbial strains, DNA, RNA, and protein microarrays, applications in diagnostics and drug discovery.

REFERENCES:

1. Cappuccino, J.G., & Welsh, C. Microbiology: A Laboratory Manual (11th Edition) Pearson Education– A foundational text covering essential and advanced microbiological techniques with detailed protocols. 2016.
2. Greenwood, D., Slack, R., & Peutherer, J. *Medical Microbiology: A Guide to Microbial Infections* (18th Edition) Elsevier– Useful for understanding diagnostic microbiology and techniques used in clinical settings. 2012.
3. Harley, J.P., & Prescott, L.M. *Laboratory Exercises in Microbiology* (9th Edition) McGraw-Hill – Offers practical exercises for mastering microbiological laboratory techniques. 2013.
4. Atlas, R.M. *Handbook of Microbiological Media* (4th Edition) CRC Press – A comprehensive resource for culture media used in a wide range of microbiological applications. 2010.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MSC5301**					
TITLE OF THE COURSE	**RESEARCH METHODOLOGY, SCIENTIFIC WRITING AND IPR**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	3	**0**	**-**	**-**	**42**	**3**

COURSE OBJECTIVES:

- Students will gain a comprehensive understanding of how to design and conduct research ethically and systematically.
- The course will develop students' ability to communicate research findings effectively through structured and impactful scientific writing.
- Students will learn the fundamentals of innovation protection, including the legal aspects of intellectual property and how to safeguard their work.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be able to understand and apply principles of research design and methodology.	L3
CO2	Design and evaluate research methodologies, including data analysis and ethical considerations	L5
CO3	Students will be able to understand various forms of intellectual property and their legal significance apply ethical principles in research and publication.	L2

COURSE CONTENT:

MODULE 1: RESEARCH METHODOLOGY **14 Hrs**

Objectives of research. Types of research. Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical. Research process. Criteria of good research. Developing a research plan. Defining the research problem. Techniques involved in defining the problem Survey of literature. Methods of data collection. Primary and secondary sources. Identifying gap areas from literature review. Development of working hypothesis. Testing of hypotheses.

Research design and methods. Features of good design. Time frame. Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan. Exploration, Description, Diagnosis, and Experimentation. Determining experimental and sample designs. Sampling – Steps, size determination and types. Good Laboratory Practices (GLP) and ethics- GLP Principles and SOP documentation.

MODULE 2: SCIENTIFIC WRITING	14 Hrs

Introduction to Scientific Writing- common types (articles, reports, reviews, thesis), Sources of scientific literature (PubMed, Scopus, Web of Science, Google Scholar). Structure of a Scientific Paper and Thesis, Literature Review and Referencing, Citation styles- APA and MLA styles of citation. Contents: Abstract, keywords, introduction, results, discussion, conclusion, Figures and Tables. Data Presentation- Effective visuals, legends, formatting, posters and oral presentations. Communication skills and handling Q&A.

Writing Research Proposals. Components of a research proposal. Budgeting and timelines. Tips for writing successful grant applications. Review and Publishing Process. Types of scientific journals and peer review process. Choosing a journal for submission. Dealing with reviewers' comments and revisions. Ethics in Scientific Writing- Plagiarism, authorship, data manipulation, conflict of interest, Peer Review and Publication Process- How to submit a paper, respond to reviewers, predatory journals.

MODULE 3: INTELLECTUAL PROPERTY RIGHTS AND PATENTS	14 Hrs

Introduction to Intellectual Property, Types of IPR (patents, copyrights, trademarks, trade secrets), Patents in Biological sciences - Patentability criteria, examples of Life science patents, Indian Patent Act, international treaties (TRIPS, WIPO), Pros and Cons of IP protection.

Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments. Patent Filing and Process- Steps of filing a patent (India and abroad), patent databases and search tools (e.g., WIPO, Espacenet). Prior art search. Types of patent applications. Licensing, IP management, technology transfer and commercialization, role of incubation centres and research institutions, Ethical and Legal Issues- Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner. Agreements and Treaties: GATT, TRIPS Agreements; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions.

REFERENCES:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology. RBSA Publishers.
2. Kothari, C.R. and Garg, G., 2019. Research Methodology: Methods and Techniques (4th ed.). New Age International Publishers.
3. Gurumani, N., 2016. Research Methodology for Biological Sciences (2nd ed.). MJP Publishers.
4. Hofmann, A.H., 2016. Scientific Writing and Communication: Papers, Proposals, and Presentations (2nd ed.). Oxford University Press.
5. Gastel, B. and Day, R.A., 2022. How to Write and Publish a Scientific Paper (9th ed.). Cambridge University Press.
6. Alley, M., 2018. The Craft of Scientific Writing (4th ed.). Springer.
7. Pandey, N. and Dharni, K., 2014. Intellectual Property Rights. PHI Learning Pvt. Ltd.
8. Mishra, J.P., 2012. An Introduction to Intellectual Property Rights. Central Law Publications.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMB5306**					
TITLE OF THE COURSE	**MULTIOMICS**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	**28**	**2**

COURSE OBJECTIVES:

- To enable the students to learn concepts of omics with special emphasis on genomics, transcriptomics, proteomics and metabolomics.
- To enable the students to understand the rapid advancements and applications of omics technologies in the different areas of biological sciences.
- To enable the students to understand fundamentals of bioinformatics and its applications

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	The students will have the knowledge of genomics: genome projects and advanced high-throughput genome sequencing technologies and latest developments in the field of ―Omics.	L1
CO2	Students will learn different methods and approaches used in transcriptomics, proteomics and metabolomics research and their applications.	L2
CO3	Students will be able to understand basics of bioinformatics and its applications in biological sciences.	L1

COURSE CONTENT:

MODULE 1: GENOMICS	**14Hrs**
Introduction to omics' technologies, Genome organization, Physical mapping of genomes, Construction of Genomic Libraries, Genome Sequencing (Chain-termination and High-Throughput Next Generation Sequencing platforms) and Genome sequence assembling strategies (Shotgun and Hierarchical/clone contig methods, sequence assembly softwares), Overview of Human Genome Project. Comparative Genomics, Metagenomics, Pharmacogenomics, Applications of genomics in identifying genetic disorders. Analysis of Transcriptome: Serial Analysis of Gene Expression (SAGE), DNA Microarrays and overview of RNA sequencing and analysis. Lipidomics, Methylomics.	
MODULE 2: PROTEOMICS AND METABOLOMICS	**14Hrs**
Introduction to proteomics, Proteome Separation, Characterization and Expression Profiling**:** 2D-PAGE (Two-Dimensional Polyacrylamide Gel Electrophoresis), 2D-DIGE (Difference in Gel Electrophoresis), Multidimensional Liquid Chromatography, Mass spectrometry and Peptide mass fingerprinting, Quantitative approaches in proteomics: Isotope Coded Affinity Tag (ICAT) method, Enzymatic and Metabolic Stable Isotope Coding, Protein Microarrays. Principles and important techniques used in Metabolomics.	

REFERENCES:

1. Xiong, J., 2006. Essential bioinformatics. Cambridge University Press.
2. Jeremy Ramsden (2015) Bioinformatics: An Introduction, Third Edition. Springer.
3. Jacques Izard, Maria C. Rivera (2015) Metagenomics for Microbiology. Elsevier.
4. D. Barcello (2014) Fundamentals of Advanced Omics Technologies: From Genes to Metabolites (Comprehensive Analytical Chemistry Volume) Elsevier B.V.
5. Edward F. Delong (2013) Microbial Metagenomics, Metatranscriptomics, and Metaproteomics (Methods in Enzymology Vol.) Elsevier Inc.
6. Encyclopedia of Genetics, Genomics, Proteomics and Bioinformatics. John Wiley & Sons. 2005.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMB5307**					
TITLE OF THE COURSE	**CLINICAL RESEARCH**					
SCHEME OF Instruction	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	2	**0**	**-**	**-**	**28**	**2**

COURSE OBJECTIVES:

- To introduce basic principles involved in preclinical evaluation of a drug, basic pharmacokinetics and dynamics of regulatory requirements for a clinical trial.
- To equip students with the proper designing and planning of clinical trial.

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will acquire sufficient knowledge on the process and regulatory perspectives of preclinical evaluation studies.	**L3**
CO2	Students will gain the concepts of designing and monitoring of clinical research studies.	**L4**

COURSE CONTENT:

MODULE 1: CONCEPTS OF CLINICAL RESEARCH	**14Hrs**

General introduction, routes of drugs administration, Dose, threshold dose, no observed effect level (NOEL), measurement of cumulative effects- time relationship. The area under the curve (AUC) of the concentration-time profiles, absolute bioavailability, Volume of Distribution (Vd). maximum tolerated dose (MTD). Basics of pharmacokinetics, calculation of pharmacokinetic estimates. Outline of drug metabolism and elimination. **Toxicity Studies**: Organ toxicity. Scheme of preclinical evaluation of toxicity study. Calculation of LD50 & ED50. Acute, subacute and chronic toxicity studies. Irwin profile test. Lipinski's rule for drug like molecule.

MODULE 2: REGULATORY PERSPECTIVES OF CLINICAL RESEARCH	**14Hrs**

Overview of Clinical Trials: Clinical evaluation of new drug, phases of clinical trial, Preparation of clinical trial. Outline of new drug development process and drugs registration.

Regulatory Perspectives of Clinical Trials: Origin and Principles of International Conference on Harmonization - Good Clinical Practice (ICH-GCP) guidelines, Ethical Committee: Institutional Review Board, Ethical Guidelines for Biomedical Research and Human Participant- Schedule Y, ICMR Informed Consent Process: Structure and content of an Informed Consent Process Ethical

principles governing informed consent process. Clinical Trials: Types and Design. Experimental Study- RCT and Non RCT, Observation Study: Cohort, Case Control, Cross sectional Clinical Trial Study, Team Roles and responsibilities of Clinical Trial Personnel: Investigator, Study Coordinator, Sponsor, CRO. Clinical Trial Documentation- Trial Monitoring- Safety Monitoring in CT Adverse Drug Reactions

REFERENCES:

1. Central Drugs Standard Control Organization- Good Clinical Practices, Guidelines for Clinical Trials on Pharmaceutical Products in India. New Delhi: Ministry of Health;2001.
2. International Conference on Harmonization of Technical requirements for registration of Pharmaceuticals for human use. ICH Harmonized Tripartite Guideline. Guideline for Good Clinical Practice.E6; May 2096.
3. Ethical Guidelines for Biomedical Research on Human Subjects 2000. Indian Council of Medical Research, New Delhi.
4. Textbook of Clinical Trials edited by David Machin, Simon Day and Sylvan Green, March 2005, John Wiley and Sons.
5. Clinical Data Management edited by R K Rondels, S A Varley, C F Webbs. Second Edition, Jan 2000, Wiley Publications.
6. Principles of Clinical Research edited by Giovanna di Ignazio, Di Giovanna and Haynes.
7. Essentials of medical pharmacology. TRIPATHI (K D). 6th edition, 2009, Jaypee Brothers Publihsers.
8. Textbook of modern toxicology. HODGSON (Ernest), 4th Ed. 2010, John Wiley.
9. Foyes principles of medicinal chemistry, WILLIAMS (David A); 5th edition, 2002, Wolter Klu Publishers.
10. Introduction to biochemical toxicology, HODGSON (Ernest); 3rd edition, 2001, Wiley Publishers.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMB5371**					
TITLE OF THE COURSE	**ADVANCED TECHNIQUES IN MICROBIOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	**6**	**-**		**3**

COURSE OBJECTIVES:

- To provide hands-on experience in molecular techniques
- To familiarize students with applied microbial techniques
- To enable students to explore the ecological and industrial significance of extremophiles and their enzymatic adaptations

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Students will be equipped with molecular techniques and its application in microbiology	L3
CO2	Students will be able to understand extremophilic adaptations and their applications	L3
CO3	Analyse and interpret results from advanced microbial assay	L4

PRACTICALS

1) Isolation of DNA from *E. coli.*
2) Isolation of RNA from *E. coli.*
3) Isolation of plasmid DNA from *E. coli.*
4) Demonstration-Restriction Enzyme digestion.
5) Demonstration- Ligation of DNA fragment.
6) Demonstration of Transformation.
7) Demonstration of Conjugation.
8) SDS-PAGE Analysis of Bacterial/Fungal Membrane Proteins.
9) Bacterial DNA amplification using PCR and Gel Electrophoresis.
10) Design and Simulation of a Synthetic Biosensor Circuit for Heavy Metal Detection (Promoter Design and Circuit Simulation using Benchling).
11) Classifying Microfluidic Droplets Based on Fluorescence Intensity Using GUI Tools (ImageJ/Fiji).
12) Identification of microorganisms using online AI tools.
13) Visit to study cultivation of mushrooms.

REFERENCES:

1) Sambrook, J., & Russell, D. W. (2001). Molecular cloning: A laboratory manual (3rd ed.). Cold Spring Harbor Laboratory Press.
2) Wilson, K., & Walker, J. (2010). Principles and techniques of biochemistry and molecular biology (7th ed.). Cambridge University Press.

3) Green, M. R., & Sambrook, J. (2012). Molecular cloning: A laboratory manual (4th ed.). Cold Spring Harbor Laboratory Press.
4) Miller, H., Harley, J. P., & Klein, D. A. (2007). Laboratory manual in molecular biology. Benjamin Cummings.
5) Snyder, L., & Champness, W. (2007). Molecular genetics of bacteria (3rd ed.). ASM Press.

SEMESTER	**III**					
YEAR	**II**					
COURSE CODE	**25MMB5372**					
TITLE OF THE COURSE	**ADVANCES IN BIOPROCESS TECHNOLOGY**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar / Projects Hours	Total Hours	Credits
	-	**0**	**6**	**-**		**3**

COURSE OBJECTIVES:

- To provide hands-on experience in the production, estimation, and analysis of microbial enzymes and metabolites
- To familiarize students with applied microbial techniques and microbial analysis of food and dairy products
- To enable students to explore the industrial significance of microbial enzymatic adaptations

COURSE OUTCOMES:

CO No.	Outcomes	Bloom's Taxonomy Level
CO1	Demonstrate the ability to isolate and quantify microbial enzymes and primary metabolites using standard biochemical and microbiological techniques.	L3
CO2	Assess the quality and safety of food and dairy products using classical and modern microbiological methods and perform microbial fermentation techniques	L3
CO3	Isolate and characterize extremophilic microbes and study their enzymatic properties and environmental adaptations	L3
CO4	Engage in experiential learning through field visits	L4

PRACTICALS

1) Production and estimation of amylase/ protease from microbial sources.
2) Estimation of lactic acid from different diary product.
3) Production and estimation of citric acid from microbes.
4) Immobilization technique: whole cell or enzyme- sodium alginate gel method.
5) Determination of quality of raw milk by methylene blue reduction test.
6) Wine production and estimation of alcohol by specific gravity method.
7) Preparation of Fermented foods and sensory evaluation.
8) Study on alkaliphiles and its enzymes (any one) isolated form extreme alkaline environment.
9) Study on halophiles isolated from high salt habitat and salt tolerance phenomenon.
10) Microbial synthesis of nanoparticles and analysis using UV spectroscopy
11) Isolation and identification of gut microbiota (any insect/larvae)/ plant endophytes.
12) Industrial visit for microbial inoculant production.

REFERENCES:

1. Casida A, Industrial Microbiology, New Age International, New Delhi.
2. Prescott S.C and Dunn C.C (2005) Industrial Microbiology, 4th Edition CBS Publishers and Distributors, New Delhi.
3. Stanbury PF, Whitakar A and Hall SJ (2009) Principles of Fermentation Technology, 2nd Edition Aditya Books (P) Ltd, New Delhi.
4. Waites Michael J., Morgan Neil., RockeyJohn S and GrayHigton. (2001). Industrial Microbiology- An Introduction, Blackwell Science. Delhi.
5. WulfCrueger (2016) A Textbook of Industrial Microbiology First CBS Publishers and Distributors Edition.
6. Robert Mellor (2009) Entrepreneurship for Everyone: A student Textbook. SAGE Publication.

SEMESTER	**IV**					
YEAR	**II**					
COURSE CODE	**25MSC5401**					
TITLE OF THE COURSE	**PROJECT**					
SCHEME OF INSTRUCTION	Lecture Hours	Tutorial Hours	Practical Hours	Seminar/Projects Hours	Total Hours	Credits
	-	**-**	**-**	**40**	**-**	**14**

- Construct a project from Plan, schedule, monitor and control students' own work and to exhibit ideas in discussions and presentations.
- Apply tools and techniques to the applied courses taught and to communicate their findings through a written report and poster presentation.

CO No.	**Outcomes**	**Bloom's Taxonomy Level**
CO1	To identify and define research problems relevant to life sciences and develop innovative solutions.	L2
CO2	To review and interpret scientific literature to support research objectives and design experiments using appropriate methodologies and techniques.	L3
CO3	To conduct independent laboratory/field research ethically and systematically and analyze and interpret experimental data using statistical tools.	L5
CO4	To communicate research findings effectively through thesis writing and presentations.	L6
CO5	To equip the students with hands-on training in Basic and applied sciences which prepares students for productive careers in Industries.	L5