ST JOSEPH'S UNIVERSITY

BENGALURU-27

DEPARTMENT OF MICROBIOLOGY

SYLLABUS FOR POSTGRADUATE PROGRAMME

From 2024 onwards

SUMMARY OF CREDITS

DEPARTMENT OF MICROBIOLOGY (PG) (2024-2026)								
Semester 1	**Code Number**	**Title**	**No of hours of instructions**	**Number of hours of teaching per week**	**Number of credits**	**Continuous Assessment (CA) Marks**	**End semester marks**	**Total marks**
Theory	MB 7124	Microbial Diversity	60	04	04	50	50	100
Theory	MB 7224	Cell Biology	60	04	04	50	50	100
Theory	MB 7324	Microbial Genetics	60	04	04	50	50	100
Theory	MB 7424	Microbiological Techniques	60	04	04	50	50	100
Practical	MB $7P_1$	Microbial Diversity and Cell Biology	88	08	04	15	35	50
Practical	MB $7P_2$	Microbial Genetics & Microbiological Techniques	88	08	04	15	35	50
Total Number of credits:			**24**					
Semester 2	**Code Number**	**Title**	**No of hours of instructions**	**Number of teaching hours per week**	**Number of credits**	**Continuous Assessment (CA) Marks**	**End semester marks**	**Total marks**
Theory	MB 8124	Microbial Physiology	60	04	04	50	50	100
Theory	MB 8224	Immunology	60	04	04	50	50	100
Theory	MB 8324	Molecular biology	60	04	04	50	50	100
Theory	MB 8424	Food Microbiology	60	04	04	50	50	100
Theory	MB 8524	Agricultural Microbiology	45	03	03	50	50	100
Practical	MB $8P_1$	Microbial Physiology & Immunology	88	08	04	15	35	50
Practical	MB $8P_2$	Food & Agricultural Microbiology	88	08	04	15	35	50
Total number of credits:			**27**					

Semester 3	**Code Number**	**Title**	**No of hours of instructions**	**Number of teaching hours per week**	**Number of credits**	**Continuous Assessment (CA) Marks**	**End semester marks**	**Total marks**
Theory	MB 9124	Recombinant DNA Technology	60	04	04	50	50	100
Theory	MB 9224	Medical Microbiology	60	04	04	50	50	100
Theory	MB 9324	Industrial Microbiology	60	04	04	50	50	100
Theory	MB 9424	Biostatistics And Bioinformatics	60	04	04	50	50	100
Theory	MB 9524	Environmental Microbiology	45	03	03	50	50	100
	-	Industrial Visit	-	-	-	-	-	-
Practical	MB $9P_1$	RDT and Medical Microbiology.	88	08	04	15	35	50
Practical	MB $9P_2$	Industrial & Environmental Microbiology	88	08	04	15	35	50
Total number of credits:			**27**					

Semester 4	**Code Number**	**Title**	**No. of Hours**	**Number of credits**	**Total marks**
Theory	MB 0424	Dissertation	360	12	350
		IGNITORS/ OUTREACH		04	
Total Number of credits:				**16**	

Total no of credits: 94

CORE COURSES (CC)	
Course Title	**Code Number**
Microbial Diversity	**MB 7124**
Cell Biology	**MB 7224**
Microbial Genetics	**MB 7324**
Microbiological Techniques	**MB 7424**
Microbial Physiology	**MB 8124**
Immunology	**MB 8224**
Molecular biology	**MB 8324**
Food Microbiology	**MB 8424**
Agricultural Microbiology	**MB 8524**
Recombinant DNA Technology	**MB 9124**
Medical Microbiology	**MB 9224**
Industrial Microbiology	**MB 9324**
Biostatistics And Bioinformatics	**MB 9424**
Environmental Microbiology	**MB 9524**

SKILL ENHANCEMENT COURSE (SEC)	
Course Title	**Code Number**
Biostatistics And Bioinformatics.	**MB 9424**
Dissertation	**MB 0424**
Microbial Diversity & Cell Biology	**MB $7P_1$**
Microbial Genetics & Microbiological Techniques	**MB $7P_2$**
Immunology and Microbial Physiology	**MB $8P_1$**
Food & Agricultural Microbiology	**MB $8P_2$**
RDT and Medical Microbiology	**MB $9P_1$**
Industrial & Environmental Microbiology	**MB $9P_2$**

Course Outcomes and Course Content

DEPARTMENT OF MICROBIOLOGY

Semester	I
Paper Code	**MB 7124**
Paper Title	**MICROBIAL DIVERSITY**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE
To study the origin and evolution of life and its diversification. To be able to comprehend, classify and have a detailed understanding of the types of microorganisms.

UNIT I **EVOLUTION AND MICROBIAL TAXONOMY**	**15**
Evolution of life on earth: Theories of origin, Selection, and types: r and K selection.	2
Microbial Taxonomy: Natural system of classification, binomial nomenclature. Concepts of taxon, species, strain. Criteria used for classification. Carl Woese- Three Domain Classification. **Classification of Bacteria**- Bergey's manual of Systematic and Determinative bacteriology. **Fungal classification** by Alexopolus and Mims (up to class level). **Classification of viruses** by the Baltimore system.	5
Recent trends in Microbial Taxonomy: **a)** Chemotaxonomy: cell wall components, lipid composition, isoprenoid-quinones, cytochrome composition. **b)** Molecular method: DNA homology, G + C ratio, rRNA sequencing (principle & type of rRNA used in specific microbe identification) **c)** Numerical taxonomy **d)** Genetic methods in taxonomy. **e)** Phylogenetic trees, methods for tree building – UPGMA & maximum parsimony	8

UNIT II **MICROBIAL DIVERSITY**	**13**
BACTERIA AND ARCHAEA **Bacteria** An overview of bacterial size, shape, and arrangement. Ultrastructure of Bacterial cell. Bacterial cell wall, Plasma membrane, mesosomes, Cytoplasmic matrix, nucleoid, Inclusion bodies, Ribosomes, Pili, Flagella, and Bacterial Motility(chemotaxis). Bacterial Endospore and sporogenesis. Reproduction by fission, budding, and conjugation. Special bacteria- Actinomycetes and Mycoplasma: Salient features and economic importance. **Archaea:** The domain Archaea, Archaeal cell walls, membranes, RNA polymerase, their metabolism and major groups of Archaea.	10 3
UNIT III **ALGAE AND FUNGI**	**15**
Introduction to algae: Occurrence of Algae- aquatic, terrestrial, epiphytic and endophytic, parasitic algae, mutualism in Algae and Fungi: Lichens. Cytology of Algae- Prokaryotic and eukaryotic, Thallus structure- Unicellular -motile and non-motile, multicellular-colonial forms. Reproduction in Algae- Vegetative, Asexual and Sexual reproduction. **Introduction to fungi:** General characteristics of fungi, morphology, and thallus organization; fungal cell, hyphae, mycelium, tissue, hyphal modifications. Ultrastructure of fungal cells: fungal cell wall, plasma membrane, cytoplasmic matrix, flagella, nuclear components. Mechanism of growth in fungi **Reproduction in fungi:** asexual, sexual and parasexual reproduction. Economic importance of fungi. **Salient features** of classes Ascomycetes, Zygomycetes, Basidiomycetes, Deuteromycetes, Oomycetes.	5 10
UNIT IV **VIRUS AND RELATED ORGANISMS**	**12**
	10

General virology: morphology and ultrastructure: capsid and their arrangements, types of envelopes and their composition, viral genome; culturing of viruses. **Bacterial viruses:** Bacteriophage structural organization, life cycle of lysogenic (lambda) phage, lytic lysogenic switch, one-step growth curve. **Plant viruses:** Structure, life cycle of: TMV. **Animal viruses:** Structure and life cycle of: a. RNA viruses: positive sense RNA virus- Poliovirus, Negative sense RNA virus- Influenza, RNA virus employing reverse transcriptase- HIV. b. DNA viruses: Poxvirus, Adenovirus. **Related organisms**: Viroid and prions.	2
UNIT V **MICROBIAL HABITATS**	**5**
a. **Classification of microbes:** based on pH, temperature, pressure and salt concentration. b. **Bacteria in extreme environments and their adaptations:** Acidophiles, Alkaliphiles, Thermophilic, Halophiles, barophilic. Extremozymes & applications. c. **Fungi utilizing various nutritional sources:** saprophytic, parasitic, keratinophilic, coprophilous, epiphytic, endophytic; substrate successions	

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

Alexopoulos, C. J., Mims, C. W., & Blackwell, M. M. (1996, January 16). *Introductory Mycology*. John Wiley & Sons.

Atlas, R. M., & Bartha, R. (1998, January 1). *Microbial Ecology*. Benjamin-Cummings Publishing Company.

Deacon, J. W. (2013, April 29). *Fungal Biology*. John Wiley & Sons.

Dimmock, N., Easton, A., & Leppard, K. (2007, January 22). *Introduction to Modern Virology*. John Wiley & Sons.

Flint, S. J., Skalka, A. M., Enquist, L. W., & Racaniello, V. R. (2009, January 1). *Principles of Virology*. Amer Society for Microbiology.

Staley, J. T. (2007, January 1). *Microbial Life*. Sinauer Associates.

Willey, J. M., Sherwood, L., & Woolverton, C. J. (2011, January 1). *Prescott's Microbiology*. McGraw-Hill Higher Education.

Sharma, O. P. (2011, January 1). *Algae*. Tata McGraw-Hill Education.

Sharma, O. P. (2011, January 1). *Fungi & Allied Microorganisms*. Tata McGraw-Hill Education.

BLUEPRINT

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	15	18
II	13	15
III	15	18
IV	12	14
V	5	06
TOTAL	**60**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the course, the student will be able to:

CO1	Gain an in-depth insight into the diverse and evolving world of microorganisms
CO2	Have a detailed understanding of the types of microorganisms
CO3	Illustrate the similarities and differences of the microbial world
CO4	Comprehend the relative importance of microorganisms
CO5	Critique the contribution of microorganisms to the larger living world
CO6	Construct evolutionary relationships among emerging microorganisms

DEPARTMENT OF MICROBIOLOGY

Semester	I
Paper Code	**MB 7224**
Paper Title	**CELL BIOLOGY**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE

Cell biology is a science that explores the structures and functions of prokaryotic and eukaryotic cells. It deciphers the mechanisms of interactions and methods of communications between cells and their environment, and helps understand the basis of various biological processes.

UNIT I **INTRODUCTION TO CELL BIOLOGY**	**2**
Basic properties of cells, diversity and Cell theory	
UNIT II **STRUCTURAL AND FUNCTIONAL ORGANIZATION OF CELLS**	**20**
Structural organization of: **Cell membrane**- Discovery of membrane structure, fluid mosaic model, bi-lipid layer **Endomembrane system**: Endoplasmic reticulum, golgi apparatus, lysosome, peroxisomes, vacuoles, mitochondria, chloroplast and nuclear organization **Cytoskeleton**: Types of cytoskeletal elements: microtubules, intermediate filaments, microfilaments– assembly and disassembly, molecular motors and sarcomere regulation, eukaryotic cell motility **Transport across membrane**: Transmembrane transport of small molecules; endocytosis and exocytosis **Vesicular trafficking**: COPI, COPII, Clathrin mediated membrane transport **Integrating cells into tissues**: Cell junctions and adhesions (cell-cell and cell-matrix),	2 4 5 2 3 3

extracellular matrix **Prokaryotic secretion systems:** Type I, II, III	1
UNIT III **CELL DIVISION, CELL CYCLE AND REGULATION**	**16**
Cell division: **Bacterial**- FtsZ division protein, MinCDE proteins, Bacterial aging **Eukaryotic**- mitosis - microtubule behavior and chromosome movement – cytokinesis - contractile ring theory **Cell cycle and regulation-** Events in cell cycle, regulation of cell cycle and cancer. Relevance of cancer stem cells, tumor marker tests, apoptosis	9 7
UNIT IV **BACTERIAL ADHESION TO HOST CELLS**	**2**
Structures involved and molecular mechanisms of microbial adhesion, effect of adhesion on host cells, pathogenicity islands	
UNIT V **CELL SIGNALING AND COMMUNICATION**	**20**
Signal transduction in prokaryotes: Two component systems- EnvZ/OmpR system Quorum sensing in gram positive, gram-negative bacteria and interspecific, bioluminescence, biofilms- organization, signals involved in their formation and dispersal, Quorum quenching and its applications **Signal transduction in eukaryotes**: Overview of extracellular signaling- major classes of receptors, secondary messengers. G-protein coupled receptors and their effectors. Receptor tyrosine kinase mediated pathways- Ras-MAP kinase pathway, JAK-STAT pathway Intracellular signaling pathway- Ca^{2+} as messenger Intercellular receptor pathway- NO as messenger	7 3 4 3 2 1

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

1. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). Molecular biology of the cell: Seventh International Student Edition with Registration Card. W.W. Norton & Company.
2. Costi D. Sifri, Quorum Sensing: Bacteria Talk Sense, Clinical Infectious Diseases, Volume 47, Issue 8, 15 October 2008, Pages 1070–1076, Sifri, C. D. (2008). Healthcare Epidemiology: Quorum sensing: Bacteria talk sense. Clinical Infectious Diseases, 47(8), 1070–1076. https://doi.org/10.1086/592072
3. Deshpande, N., & Rangarajan, A. (2015). Cancer stem cells: formidable allies of cancer. Indian Journal of Surgical Oncology, 6(4), 400–414. https://doi.org/10.1007/s13193-015-0451-7
4. Gross, R., Aricò, B., & Rappuoli, R. (1989). Families of bacterial signal-transducing proteins. Molecular Microbiology, 3(11), 1661–1667. https://doi.org/10.1111/j.1365-2958.1989.tb00152.x
5. Karp, G. (2009). Cell and molecular biology: Concepts and Experiments. John Wiley & Sons.
6. Kostakioti, M., Hadjifrangiskou, M., & Hultgren, S. J. (2013). Bacterial biofilms: development, dispersal, and therapeutic strategies in the dawn of the postantibiotic era. Cold Spring Harbor Perspectives in Medicine, 3(4), a010306. https://doi.org/10.1101/cshperspect.a010306
7. Lodish, H. F. (2000). Molecular Cell Biology. Scientific American Library.
8. Stewart, E. J., Madden, R., Paul, G., & Taddéi, F. (2005). Aging and death in an organism that reproduces by morphologically symmetric division. PLOS Biology, 3(2), e45. https://doi.org/10.1371/journal.pbio.0030045

BLUEPRINT

Code number: MB 7224

Title of the paper: CELL BIOLOGY

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	2	2
II	20	24
III	16	19
IV	2	2
V	20	20
TOTAL	**60**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

CO1	Gain knowledge of organisms at the cellular level
CO2	Identify and understand the basic structure and functions of prokaryotic and eukaryotic cells
CO3	Acquire in depth knowledge of the structural complexities of cells, study the intracellular and intercellular interactions of cells.
CO4	Understand how prokaryotic and eukaryotic cells communicate amongst themselves using various diffusible signals.
CO5	Assess how pathogens can exploit cellular mechanisms to infect host cells and establish an infection.
CO6	Apply the knowledge of cellular communications between pathogens to develop strategies to combat infections

DEPARTMENT OF MICROBIOLOGY

Semester	I
Paper Code	**MB 7324**
Paper Title	**MICROBIAL GENETICS**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE:

This paper aims at gaining knowledge on the basic concepts and mechanisms in microbial genetics. It strengthens the understanding of the intricacies of cells at the molecular level.

UNIT I	**15**
a. Historical Perspective: (i) DNA as the source of genetic information in bacteria and viruses: Griffith's experiment, Avery's experiment, Hershey and Chase experiment. (ii) RNA as the source of genetic information in TMV - Frankel-Conrat's experiment, Retrovirus (HIV)	**3**
b. Organization and Molecular structure: DNA structure, forms of DNA, DNA topology, DNA supercoiling, VNTRs, mini and micro genomes, Satellite DNA, Structure of RNA (Unusual forms: Tetraloop, Pseudoknot and U:A:U base triple). Genome organization (prokaryotes).	**9**
c. Properties of DNA: Denaturation, Renaturation (Filter binding assay and concentration dependent renaturation) and DNA heteroduplexes, G-quadruplexes.	**2**
d. DNA constancy and C-value paradox.	**1**
UNIT II	**4**
BACTERIAL PLASMIDS: General features, Types of natural plasmids, F-factors- description and their used in genetic analysis, Colicins and Col factors. Plasmid DNA replication. Applications of plasmids in genetic engineering. Regulation of copy number and compatibility of plasmids	

UNIT III	**8**
DNA REPLICATION IN PROKARYOTES DNA replication in Prokaryotes: Origin of replication, replication fork, leading and lagging strand, semi conservative replication, rolling circle and looped rolling circle replication, enzymes involved in prokaryotic replication and DNA proof reading.	
UNIT IV	**10**
BACTERIAL AND VIRAL GENETICS: **a.** Mechanism and Applications of bacterial transformation, Transduction, Conjugation, Complementation and Transfection. Transformation mapping, Mapping through interrupted mating, Transduction Mapping. **b.** Genomic organization, replication and significance of viruses: T4, P1, M13, ϕX174. c. Two component system: Toxin antitoxin systems in the evolutionary arms race of phage and bacteria	**6** **3** **1**
UNIT V	**5**
TRANSPOSABL ELEMENTS: Overview of transposable elements in bacteria (IS elements, composite transposons and non-composite transposons) and eukaryotes (yeast Ty elements, P elements of *Drosophila*); Sleeping Beauty transposon system. Applications of transposons in genetic engineering.	
UNIT VI	**11**
DNA MUTATION AND REPAIR: **a. Gene mutation:** Genes as unit of mutation, Molecular basis of spontaneous and induced mutations and their role in evolution, mutagens, types of mutation, site-directed mutagenesis, Mutational hot spots, environmental mutagenesis and toxicity testing – AMES test. **b. Reversion:** Same site revertant, Second site revertant, Second site revertant of frameshift mutations, intergenic reversion. **c. Repair:** Biological indication of repair, Biochemical mechanisms for repair of thymine dimmers-Photoreactivation, Excision repair, Recombination repair, SOS repair.	**6** **2** **3**
UNIT VII	**7**
a. Recombination: Holliday Model; Double Strand Break Repair Model; Role of RecA, Rec BCD, RuvAB and RuvC in recombination. **b. Site-Specific Recombination:** Types: Conservative site-specific	**2**

	recombination -recombination by serine recombinase; (ii) Transpositional recombination- Definition and mechanism of (a) DNA transposons-cut and paste mechanism, replicative mechanism; (b) viral-like retrotransposons- use of RNA intermediate and (iii) polyA retrosposons–reverse splicing mechanism.	**4**
c.	Importance of mutation and recombination in the evolution of pathogens and Generation of knockouts.	**1**

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

1. Freifelder, D. (1987). *Molecular Biology*. Jones & Bartlett Publishers.
2. Gardner, Simmons, M. J., & Snustad, D. P. (2006). *Principles of Genetics, 8th ed*. John Wiley & Sons.
3. Gardner, Simmons, M. J., & Snustad, D. P. (2006b). *Principles Of Genetics, 8th ed*. John Wiley & Sons.
4. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. (2019). *Concepts of Genetics, Global Edition*.
5. Lewin, B., Krebs, J., Kilpatrick, S. T., & Goldstein, E. S. (2011). *Lewin's GENES X*. Jones & Bartlett Learning.
6. Nelson, D. L. (2016). *Principles of Biochemistry 7e*.
7. Pierce, B. A. (2012). *Genetics: a Conceptual Approach*. Macmillan.
8. Watson, J. D., Baker, T. A., & Bell, S. P. (2014). *Molecular biology of the gene*. Benjamin-Cummings Publishing Company.

BLUEPRINT

Code number: MB 7324
Title of the paper: MICROBIAL GENETICS

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	15	18
II	4	5
III	8	9
IV	10	12
V	5	6
VI	11	13
VII	7	8
TOTAL	**60**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

CO1	Gain knowledge in the basic concepts of Microbial Genetics
CO2	Attain insight into the genetic processes of microbes
CO3	Execute the knowledge in practical demonstration of various genetic processes
CO4	Analyze distinct genomic datasets to construct linkage mapping.
CO5	Assess the importance of proteins and enzymes in genetic mechanisms
CO6	Design and conduct experiments in applied Microbiology

DEPARTMENT OF MICROBIOLOGY

Semester	I
Paper Code	**MB 7424**
Paper Title	**MICROBIOLOGICAL TECHNIQUES**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE
This paper enables a student to identify microbes, analyze and characterize biomolecules using various techniques.

UNIT I	**5**
PROPERTIES OF WATER Structure and interactions, water as a solvent, Proton mobility, Ionization of water, Non- covalent interactions of biomolecules.	2
ACIDS- BASES AND BUFFERS Acid-base reactions (titration curve), Buffers (Henderson-Hasselbach equation), Biological buffers (Phosphate and Bi carbonate buffer)	3
UNIT II **MICROSCOPY AND STAINING**	**15**
a. **Principles of Microscopy** (Properties of light)	2
b. **Light Microscopy** Bright Field Microscope, Phase Contrast Microscope, Dark Field Microscope, Fluorescence Microscope, Stereo Microscope. Preparation and staining of specimen (simple, differential and structural staining),	6
c. **Electron Microscopy** Transmission Electron Microscope, Scanning Electron Microscope, Cryo-EM	3
d. **Newer techniques in Microscopy** Scanning Tunneling Microscope, Confocal Microscope, Atomic Force Microscope	3
e. Image analysis	1

UNIT III **STERILIZATION TECHNIQUES AND BIOASSAY**	**13**
STERILIZATION TECHNIQUES a. Control of microorganisms by physical agents Fundamentals of control, Physical agents (high temperature, low temperature, desiccation, osmotic pressure, radiation, surface tension and interfacial tension, filtration) b. Control of microorganisms by chemical agents Characteristics of an ideal antimicrobial chemical agent, Major groups of antimicrobial agents (phenol and phenolic compounds, alcohols, halogens, heavy metals, dyes, detergent, quaternary ammonium compounds, aldehydes, gaseous agents), Evaluation of antimicrobial chemical agents (tube dilution and agar plate techniques, phenol coefficient method) **BIOASSAYS** Introduction to Bioassays - Antibacterial, antiviral and anticancer.	4 5 4
UNIT IV	**22**
SEPARATION TECHNIQUES (PRINCIPLES, METHODS AND APPLICATIONS) a. Chromatography (Thin layer chromatography, Ion exchange, Size exclusion, Affinity, gas and HPLC chromatography) b. Centrifugation (Preparative and Analytical) c. Electrophoresis (Horizontal and Vertical) d. Cell sorting (FACS)	10
SPECTROSCOPY (PRINCIPLES, METHODS AND APPLICATIONS) Ultraviolet and Visible light spectroscopy, Fluorescence spectroscopy, IR spectroscopy, Mass spectroscopy (GC-MS, LC-MS, MALDI TOF), Circular dichroism, NMR.	12
UNIT V **MOLECULAR METHODS OF MICROBIAL COMMUNITY ANALYSES**	**5**
Phospholipids fatty acid analysis and nucleic acid techniques - DGGE/TGGE, RISA, SSCP, RAPD, PCR; fluorescent in situ hybridization (FISH).	

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

1. Atta-Ur-Rahman, Choudhary, M. I., & Thomsen, W. J. (2001). *Bioassay techniques for drug development.* CRC Press.
2. Black, J. G. (2019). *Microbiology: Principles and Explorations*.
3. Freifelder, D. (1976). *Physical biochemistry: Applications to Biochemistry and Molecular Biology*.
4. Nelson, D. W., & Cox, M. (2021). *Lehninger Principles of Biochemistry, 7th ed*.
5. Pelczar, M. J., Reid, R. D., & Chan, E. C. S. (1977). *Microbiology*. McGraw-Hill Science
6. Professor, C. J. W., Sherwood, L., & Willey, J. (2019). *Prescott's Microbiology*. McGraw-Hill Education.
7. Rastogi, G., & Sani, R. K. (2011). *Molecular techniques to assess microbial community structure, function, and dynamics in the environment*. In Springer eBooks (pp. 29–57).

BLUEPRINT

Code number: MB 7424
Title of the paper: MICROBIOLOGICAL TECHNIQUES

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	5	6
II	15	18
III	13	15
IV	22	26
V	5	6
TOTAL	**60**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

CO1	Develop a good understanding of various techniques and instruments used in Microbiology
CO2	Understand the basic concepts of different techniques used to study microorganisms and biomolecules and apply biophysical principles to biological processes.
CO3	Apply the knowledge to handle various basic/advanced techniques to isolate and characterize microorganisms.
CO4	Compare and contrast the significance of various techniques
CO5	Critically evaluate and communicate scientific data
CO6	Design experiments for research problems.

MB7P$_1$: MICROBIAL DIVERSITY AND CELL BIOLOGY

88 hours/22 Units

S. No.	Experiments	Unit(s)
	BACTERIOLOGY	
1.	Isolation and identification of bacteria: **a.** Cultural characteristics of bacteria on NA **b.** Pure culture techniques (Types of streaking) **c.** Staining techniques: Gram's, Negative, Endospore, Capsule and Cell Wall **d.** Isolation of Actinomycetes from natural sources	3
2.	Biochemical characterization of bacteria: IMViC Tests, Carbohydrate fermentation test (HiIMViC Biochemical Test Kit) Mannitol motility test, Gelatin liquefaction test, Urease test, TSI test, Nitrate reduction test, Catalase test, Oxidase test, Starch hydrolysis, Casein hydrolysis	4
3.	Isolation of cellulolytic and anaerobic sulphate reducing bacteria using a Winogradsky column	2
4.	Isolation and characterization of extremophiles: acidophilic, alkalophilic and halophilic bacteria	2
	MYCOLOGY	
5. 6.	Isolation and identification of Saprophytic and Coprophilous fungi Effect of temperature and pH on the growth of fungi	2
	PHYCOLOGY	
7. 8.	Isolation and identification of microalgae Type study of algae and Cyanobacteria – *Scytonema, Spirullina*, *Anabaena, Nostoc*	2
	VIROLOGY	
9.	Isolation of bacteriophages from sewage	2
	CELL BIOLOGY	
10.	Study of Mitosis	0.5
11.	Vital staining of mitochondria	0.5
12.	Study of quorum sensing by *Chromobacterium violaceum*	1

13.	Detection of chemoreceptor mediated chemotaxis using Chemical Gradient Motility Agar	1
14.	Production and quantification of biofilm by using microorganisms (Plate; Tube and Microtiter plate method)	2

REFERENCES:

1. Aneja, K. R. (2007). *Experiments in microbiology, plant pathology and biotechnology*. New Age International.
2. Cappuccino, J. G., & Sherman, N. (2013). *Microbiology: A Laboratory Manual*. Pearson Educacion.
3. Sharma, K. (2007). *Manual of Microbiology: Tools & Techniques*. Anshan Pub.
4. Singer, S. (2001). *Experiments in Applied Microbiology*. Academic Press.

MB7P$_2$: MICROBIAL GENETICS AND MICROBIOLOGICAL TECHNIQUES

88 hours/22 units

Microbial Genetics		
S No	**Experiments**	**Unit(s)**
1	Mutagenesis by chemical agents like EtBr/methyl methane sulphonate (MMS), diethyl sulphate/nitrosoguanidine (NTG)	2
2	Ames Test	2
3	Isolation of genomic DNA and analysis by agarose gel electrophoresis	2
4	Isolation of plasmid DNA and analysis by agarose gel electrophoresis	2
5	Conjugation in *E. coli*	2
6	Isolation of antibiotic resistant bacterial population by gradient plate method	2
Microbiological Techniques		
S No	**Experiments**	
1	Buffer preparation and titration	1
2	Micrometry	1
3	Hemocytometry	1
4	Phenol Coefficient method to test the efficacy of disinfectants	2
5	Effect of antibiotics and heavy metals on bacteria and fungi	2
6	Separation of amino acids using Thin Layer Chromatography	1
7	Demonstration - HPLC, GC-MS	2

REFERENCES:

1. Aneja, K. R. (2007). *Experiments in microbiology, plant pathology and biotechnology*. New Age International.
2. Cappuccino, J. G., & Sherman, N. (2014). *Microbiology: A Laboratory Manual*. Benjamin Cummings.
3. Manickam, A., & Sadashivam, S. (2010). *Biochemical methods*.

DEPARTMENT OF MICROBIOLOGY

Semester	II
Paper Code	**MB 8124**
Paper Title	**MICROBIAL PHYSIOLOGY**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE:

It enables a student to understand microbial cell functions which includes the study of microbial growth and metabolism.

UNIT I **MICROBIAL NUTRITION**	**10**
a. Nutritional types of microorganisms	2
b. Uptake of Nutrients: Passive and facilitated diffusion, Primary and Secondary Active transport, Group Translocation, Iron uptake, ATP linked Ion motive pumps (P-class, F-class, V-class pump and ABC superfamily).	4
c. Microbial stress responses- Osmotic stress, oxidative stress, thermal stress and heat shock response, nutrient stress and starvation stress response.	4
UNIT II **BIOENERGETICS**	**4**
Laws of thermodynamics, Thermodynamic quantities (Gibb's free energy, Enthalpy, Entropy), Biological oxidation reduction reactions, high energy compounds-ATP, NAD, FAD, FMN.	
UNIT III **CARBOHYDRATES**	**20**
a. Structure (mono, di, and polysaccharides)	3
b. Introduction to metabolism	1
c. Carbohydrate metabolism: Glycogenolysis, Glycolysis and its regulation, TCA cycle and its regulation, Electron transport and Oxidative phosphorylation, Pentose phosphate pathway, Glyoxylate cycle, Gluconeogenesis, Biosynthesis of peptidoglycan, Entner-Duodroff pathway.	8

d. Fermentation: Lactic acid fermentation, Alcoholic fermentation., mixed acid fermentation	2
e. Concept of metabolic engineering with suitable examples	2
f. General Features of Photophosphorylation **Light reactions:** Oxygenic and anoxygenic photophosphorylation. **Dark reactions (CO_2 fixation):** Calvin cycle (C_3 pathway) and C_4 pathway. CO_2 fixation in microorganisms.	4
UNIT IV **AMINO ACIDS, PROTEINS AND NUCLEOTIDES**	**8**
a. Amino acids: Structure, classification and properties of amino acids.	2
b. Amino acid metabolism: General aspects of amino acid metabolism (Transamination, deamination, decarboxylation), urea cycle, uric acid biosynthesis.	2
c. Proteins: Structural organizations of proteins (primary, secondary, tertiary and quaternary structure).	2
d. Nucleotides Structure, Biosynthesis and degradation of nucleotides	2
UNIT V **ENZYMES**	**12**
a. Introduction and Classification	2
b. **Concepts and Mechanism of enzyme action:** Active site and allosteric site. Lock and key theory, induced fit theory, acid-base catalysis, covalent catalysis, metal ion catalysis.	2 4
c. **Enzyme Kinetics** as an approach to understanding mechanism - Michaelis Menten kinetics, transformation of Michaelis Menten equation to Lineweaver Burk equation (double reciprocal plot), interpreting Km and Vmax, comparing catalytic mechanisms and efficiencies enzymes, multisubstrate enzyme kinetics and factors affecting enzyme kinetics	1 2
d. **Regulatory enzymes**	1
e. **Enzyme inhibition**: Reversible, Irreversible, Competitive, Uncompetitive and Non-competitive.	
f. Isozymes and abzymes.	
UNIT VI **LIPIDS**	**6**
a. Classification, physical and chemical properties	3
b. Lipid metabolism: Oxidation of saturated fatty acids – β oxidation pathway, Biosynthesis of straight chain even carbon saturated fatty acid (palmitic acid)	3

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

1. Atlas, R. M., & Parks, L. C. (1995). *Principles of microbiology*. WCB/McGraw-Hill.
2. Branden, C. I., & Tooze, J. (2012). *Introduction to protein structure*. Garland Science.
3. Campbell, M. K., Farrell, S. O., & McDougal, O. M. (2020b). *Biochemistry*.
4. Creighton, T. E. (1993). *Proteins: Structures and Molecular Properties*.
5. Garrett, R. H., & Grisham, C. M. (1995). *Biochemistry*. Harcourt Brace College Publishers.
6. Moat, A. G., Foster, J. W., & Spector, M. P. (2003). *Microbial physiology*. John Wiley & Sons.
7. Nelson, D. W., & Cox, M. (2021). *Lehninger Principles of Biochemistry,* 7th ed.
8. Price, N. C., & Stevens, L. (1999). *Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins*. Oxford University Press, USA.
9. Voet, D., Voet, J. G., & Pratt, C. W. (2016). *Fundamentals of Biochemistry: Life at the Molecular Level*. John Wiley & Sons.
10. Professor, C. J. W., Sherwood, L., & Willey, J. (2016). *Prescott's Microbiology*. McGraw-Hill Education

BLUEPRINT

Code number: MB 8124
Title of the paper: MICROBIAL PHYSIOLOGY

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	8	9
II	15	18
III	20	24
IV	10	12
V	7	8
TOTAL	**60**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

CO1	Develop a sound knowledge of biomolecules, bioenergetics, uptake and assimilation of nutrients during microbial growth.
CO2	Compare and contrast the different aspects of metabolic pathways that various organisms employ.
CO3	Experiment with /develop conditions for the growth of microorganism
CO4	Categorize microorganisms based on the assimilation pattern of nutrients and analyze biomolecules.
CO5	Critique the role of enzymes, coenzymes and cofactors involved in various pathways
CO6	Hypothesize the alternative pathways for assimilation of nutrients by metabolic engineering

DEPARTMENT OF MICROBIOLOGY

Semester	II
Paper Code	**MB 8224**
Paper Title	**IMMUNOLOGY**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE

To understand the ability of our immune system to defend against invading pathogens in a logical sequence. This includes our innate ability and mechanisms to defend against microorganisms (innate immunity). If this first line of defense fails, how we can fight infections (acquired immunity). If we react excessively, what price we pay (hypersensitivity); if our defense is misdirected, what are the consequences (autoimmunity) and very importantly, preventing pathogens from infecting us (vaccination).

UNIT I	**18**
Types of immunity: Definition, innate, acquired- active and passive with examples. Factors affecting immunity**:** age, hormonal influence, nutrition. Mechanisms of innate immunity: Anatomical, Physiological, Phagocytotic and Inflammatory response. Hematopoiesis: Hematopoietic growth factors, genes that regulate hematopoiesis, regulation of hematopoiesis, programmed cell death, ontogeny, development and functions of cells in innate and adaptive immunity. Cells of the immune system (T-cells, B-cells, Natural Killer cells, Macrophages, Antigen presenting cells, Neutrophils, Eosinophils, Basophils, Mast cells and Dendritic cells). Mechanism of antigen recognition and activation by T and B cells. Organs of the Immune system: Structure and function of Primary and Secondary Organs	
UNIT II	**15**
Antigens: characteristics, types, cross reactivity, hapten, adjuvant, immunogenicity and antigenicity. Immunoglobulins: types, structure and functions, Molecular biology of immunoglobulin synthesis, antibody diversity, isotype switching.	

Immunotechnology: Production of monoclonal antibodies, Applications of Mab –Diagnostic, therapeutic and immunopurification. Antigen antibody interactions**:** Principles and methods of Precipitations, Agglutinations**,** ELISA, RIA, Immunofluorescence, Complement fixation. Neutralization	
UNIT III	**12**
Immune response: Humoral, primary and secondary responses, factors influencing antibody production and Cellular immune response. Mechanisms of Immunological Tolerance: T and B cell tolerance. Immune effector mechanisms: Cytokines properties and functions. Complement System: General Properties, components, complement activation, Classical, alternate pathway. Regulations of the complement system, biological consequences of complement activation, and complement deficiencies. Hypersensitivity: Anaphylaxis, cytotoxic, immune complex deposition and cell mediated.	
UNIT IV	**15**
Immunity to infectious diseases: Bacterial, viral Auto immunity: Classification and mechanisms of autoimmune diseases. Structure and functions of class I and class II MHC molecules and HLA typing Transplantation immunology: Graft versus host reactions, Principles of tumor immunology: Tumor antigens, immune response to tumor, and immunotherapy of malignancy. Vaccines: classification: inactivated, live attenuated, subunit, synthetic, DNA and plant vaccine. Vaccine production strategies, identification and analysis of vaccines	

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

1. Abbas A.K., A.H. Liehtman and J.S. Pober 2000. **Cellular and molecular Immunology** 9th edition V.B. Saunders Company, London.
2. Charles A Janeway, Paul Travers, Mark Walport. **Immunobiology: The Immune System in health and Disease**. 6th Edition Churchill publication August 2004.
3. Coleman, R.M., Lombard, M.F., and R.E. Sicard, 1992, **Fundamental of immunology**, third edition, Wm.C. Brown Publishers, USA.
4. Cruse, J.M. and R. Lewis, 1999 **Atlas of Immunology**, third edition CRC Press, New York May 2010.
5. Janeway, Jr.C.A. andP.Travers 2001 **Immunobiology**, 9th edition Garland Publishing, London.

6. Jenni Punt, Sharon Stranford, Patricia Jones and Judith A Owen -**Kuby Immunology**, Eighth edition.W.H. Freeman and Company, New York.
7. Michael J.H Ratcliffe. **Encyclopedia of immunology,** first edition academic press 2016.
8. Noel R. Rose, Robert G. Hamilton and Barbara Detrick (Eds.) **Manual of Clinical Laboratory and Immunology** 6th Edition. 2002, ASM Publications.
9. Peter J. Delves, Seamus J. Martin, Dennis R Burton, Ivan Roit. **Roitt's Essential Immunology**,13th edition Wiley Blackwell.
10. Richard Coico, Geoffery Sunshine and Eli Benjamin - **Immunology: A Short course**, 5th edition - Wiley–Blackwell; (14 November 2003).
11. Sudha S. and Subhanghe Sonkatte- **A text book of basic and clinical immunology**-Orient Blackswan.
12. Sulabha Pathak., Urmi. Palan., Immunology **– Essential and Fundamental** 3rd edition Science publishers-2005

BLUEPRINT

Code number: MB 8224
Title of the paper: IMMUNOLOGY

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	18	21
II	15	18
III	12	14
IV	15	18
TOTAL	**60**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

CO1	Gain insight into the role and complexity of the defense/immune system against various threats posed to the body by infectious organisms.
CO2	Understand the basic principles, concepts and techniques pertaining to the immune system, its organization and the complex mechanisms used to perform various functions.
CO3	Analyze serological techniques for diagnosis /research and to compare and contrast various immunological responses.
CO4	Critically examine the clinical data/reports
CO5	Assess and interpret the mechanisms/strategies for prevention and protection against diseases.
CO6	Gain insight into designing and developing vaccines, diagnostic kits and therapeutics.

DEPARTMENT OF MICROBIOLOGY

Semester	II
Paper Code	**8324**
Paper Title	**MOLECULAR BIOLOGY**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE

This paper aims to introduce the students to the finer aspects of life processes at the molecular level. It defines the regulation of gene expression and its diverse effects from metabolic utilization of sugars to complex events underlying the development of an organism. This paper is an attempt to peek into the vast subject of ever-evolving field of Molecular biology which has promising research and industrial applications.

UNIT I	**5**
REPLICATION IN EUKARYOTES Structure of eukaryotic chromosome (Chromatin- Nucleosome model and packaging). Pre replicative complex, DNA polymerase and enzymes involved in replication, Process of replication, Regulation of replication. End replication problem and telomerase. Inhibitors of DNA replication. Comparative account of prokaryotic and eukaryotic replication	
UNIT II	**15**
TRANSCRIPTION IN PROKARYOTES AND EUKARYOTES: RNA polymerase – structure, properties and functions Initiation – promoters – upstream & downstream sequence, Sigma and Transcription factors. Elongation Termination – Rho dependent and Rho independent. Structure and function of mRNA and tRNA Post transcriptional modifications of RNA (rRNA, tRNA and mRNA) Inhibitors of transcription. **Reverse transcription – Reverse transcriptase.**	

UNIT III	**15**
TRANSLATION: Genetic code: Elucidation of Triplet code, code characteristics, codon dictionary. Structure of Ribosomes and its constituents in prokaryotes and eukaryotes. Amino acyl tRNA synthetase function and proofreading. Process of translation in prokaryotes and eukaryotes. Initiation – Initiation factors, Initiator tRNA, Amino acid activation, Shine-Dalgarno sequences, Initiation site. Elongation – Elongation factors and Translocation. Termination – Termination codons and releasing factors Inhibitors of translation and control of translation in eukaryotes (SsrA rescue system, nonsense and nonstop mediated decay)	
UNIT IV	**8**
PROTEIN SORTING: Signal hypothesis Transport between the nucleus and cytoplasm, transport into mitochondria, chloroplast and vesicular trafficking of proteins. Overview of the path of secretory protein (brief). **Post Translational modification and folding.**	
UNIT V	
A) REGULATION OF GENE EXPRESSION IN PROKARYOTES- Operon concept – positive and negative mechanisms of control (general concepts). Lactose system – Coordinate regulation, Lac operon, Positive and negative regulation, Catabolite repression, lac mutant (problems on phenotype and genotype variation) Tryptophan operon, Attenuation. Arabinose operon and its regulation. Role of sigma factor in regulation, antitermination and riboswitches.	**9**
B) EUKARYOTIC GENE EXPRESSION REGULATION – Britten Davidson model of gene regulation (concept). Regulatory proteins. Epigenetic regulation (HAT, HDAC, Methylation). Chromatin remodeling (HAT and HDAC,), Hormonal regulation, Alternate splicing, RNA editing, Gene silencing.	**8**

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014, November 18). *Molecular Biology of the Cell*. Garland Science.
2. Lodish, H. F., Berk, A., Kaiser, C. A., Krieger, M., & Scott, M. P. (2007, August 30). *Molecular Cell Biology*. W H Freeman & Company.
3. Gardner, E. J., Simmons, M. J., & Snustad, D. P. (1991, January 1). *Principles of Genetics*.
4. Freifelder, D. (1993, January 1). *Essentials of Molecular Biology*. Jones & Bartlett Publishers.
5. Lewin, B. (2004, January 1). *Genes VIII*.
6. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008, January 1). *Lehninger Principles of Biochemistry*.
7. Pierce, B. A. (2012, January 1). *Genetics: A Conceptual Approach*. Macmillan.
8. Watson, J. D., Baker, T. A., & Bell, S. P. (2014, January 1). *Molecular Biology of the Gene*. Benjamin-Cummings Publishing Company.

BLUEPRINT

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	05	06
II	15	18
III	15	18
IV	08	09
V	17	20
TOTAL	**60**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

CO1	Gain knowledge on the intricacies of molecular functioning of a cell
CO2	Understand the life processes and their regulation.
CO3	Apply the knowledge gained to compare between a healthy/unhealthy and faulty system.
CO4	Analyze the similarities and differences in the cellular functioning of a prokaryotic and eukaryotic system and draw inferences that can benefit translational research.
CO5	Assess how disruptions in the normal life processes can lead to diseased conditions.
CO6	Identify potential therapeutic targets to combat disorders and diseases.
CO7	Modify molecular processes to harness products of industrial and pharmaceutical importance.

DEPARTMENT OF MICROBIOLOGY

Semester	II
Paper Code	**MB 8424**
Paper Title	**FOOD MICROBIOLOGY**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE
This paper is designed to broaden the understanding of the potential applications of microorganisms, modern techniques, and safety involved in the field of Food Sciences.

UNIT I	**10**
INTRODUCTION TO FOOD MICROBIOLOGY: Definition, concepts and scope. Food as substrate for microbes. Factors influencing microbial growth in food-Extrinsic and intrinsic factors. Hurdle effect. Predictive food Microbiology **CONTAMINATION AND FOOD SPOILAGE:** Sources of food contamination. Principles of food spoilage; Spoilage of Cereals, sugar products, vegetables, fruits, meat and meat products, sea foods, poultry; spoilage of canned foods.	
UNIT II	**9**
DAIRY MICROBIOLOGY: (a) Composition and types of milk, Microbiology of raw and processed milk, Milk as a vehicle of pathogens, Change in microflora of milk (b) Analysis and Microbiological standards for milk - Rapid Platform Tests, SPC, DMC, Coliform count (MPN), Dye reduction tests (c) Prevention of contamination of raw milk - Pasteurization and its methods; Tests to determine the efficiency of pasteurization - alkaline phosphatase test & Lactoperoxidase test (d) Sources of contamination of milk and adulteration of milk	

(e) Spoilage and defects of milk and milk products	
UNIT III	**11**
(a) Lactic starter cultures. (b) Fermented foods-(i) Curd/Yoghurt, Cheese, Acidophilous milk. (ii) Idli batter (iii) Sauerkraut, Soy sauce, Natto (iv)Sausages (v) Olives and Cocoa. (c) Probiotics, Prebiotics and Nutraceuticals (d) SCP and SCO. (e) Fortified foods. (f) Effect of food on normal gut flora. (g) Processed food: Definition and types, breakfast cereals, canned foods (vegetables and meat). (h) Food designed for space exploration.	
UNIT IV	**8**
FOOD PRESERVATION TECHNIQUES: Principles of food preservation- Chemical preservatives and Food additives, asepsis, High temperature (D, F, Z values), Low temperature, Drying, Radiation, Canning and Packaging of foods- Types of packaging materials, properties and benefits. Classification of Preservatives and Food Labelling.	
UNIT V	**7**
FOOD BORNE ILLNESS: Food borne diseases caused by *Listeria sp*, *Salmonella sp*, *Campylobacter jejuni*, *Clostridium botulinum*, Mycotoxins and food borne viruses (Hepatitis A)	
UNIT VI	**10**
MICROBIAL DETECTION AND FOOD SAFETY: Indicator organisms - Coliforms, Enterococci, Bifidobacteria, Coliphages and Enteroviruses Quantitative methods for microbial enumeration in foods Test and detection of toxins in food. Biosensors in pathogen detection. **FOOD SANITATION AND CONTROL:** Good Manufacturing Practices, Good Hygienic Practices, Hazard Analysis and Critical Control points. (HACCP), Food control Agencies - AGMARK, BIS, ISO 9000, ISO 22000, PFA, FSSAI.	
UNIT VII	**5**
WASTE MANAGEMENT AND VALORIZATION Types of waste generated in the food industry: Degradable and non-degradable. Waste from (1) fruit and vegetable processing industry,	

(2) fish, meat and poultry and dairy industry. Methods of utilizing waste to make value added products; pectin, food colorants, antioxidants from fruit peels (citrus, mango, pomegranate), lycopene from tomato peels, enzymes from meat processing.	

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

1. Adams, M. R., & Moss, M. O. (2008). *Food Microbiology*. Royal Society of Chemistry.
2. Flickinger, M. C. (2010). *Encyclopedia of Industrial Biotechnology, 7 volume Set: Bioprocess, Bioseparation, and Cell Technology*. Wiley.
3. Hayes, R. (2013). *Food Microbiology and Hygiene*. Springer Science & Business Media.
4. Jay, J. M., Loessner, M. J., & Golden, D. A. (2008). *Modern Food Microbiology*. Springer Science & Business Media.
5. Matthews, K. R., Kniel, K. E., & Montville, T. J. (2020). *Food Microbiology: An Introduction*. John Wiley & Sons.
6. Todaro, C. M., & Vogel, H. C. (2014). *Fermentation and Biochemical Engineering handbook*. William Andrew.
7. William, C. Frazier & Dennis C Westhoff. (2017). Food Microbiology. McGraw Hill Education.

BLUEPRINT

Code number: MB 8424

Title of the paper: FOOD MICROBIOLOGY

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	10	12
II	9	11
III	11	13
IV	8	9
V	7	8
VI	10	12
VII	5	6
TOTAL	**60**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

CO1	Gain a broader insight into the positive and negative interactions of microbes in food along with the significance of food preservation and safety
CO2	Compare various strategies for microbiological analysis of food, food preservation and safety (regulations & compliance requirements)
CO3	Incorporate the principles of food microbiology in practical and real-world scenarios
CO4	Identify and analyze potential problems and causes of food contamination and spoilage, illness, safety and quality control
CO5	Assess various approaches and remedies to the identified issues and drawbacks in food microbiology
CO6	Design potential strategies to suit pertinent issues in food microbiology and food safety
CO7	Comprehend the impacts of waste and effects of waste management on the environment. Investigate sustainable waste management strategies and be aware of extended producer responsibility.

DEPARTMENT OF MICROBIOLOGY

Semester	II
Paper Code	**MB 8524**
Paper Title	**AGRICULTURAL MICROBIOLOGY**
Number of teaching hours per week	3
Total number of teaching hours per semester	45
Number of credits	3

OBJECTIVE
To understand the intricate microbial interactions, host-parasite relationship, and plant protection for better growth and yield of crop plants.

UNIT I **MICROBIAL INTERACTIONS**	**15**
Nitrogen cycle: Fixation of atmospheric nitrogen, ammonification, nitrification, and denitrification. Symbiotic and non-symbiotic nitrogen fixation, nif genes, Nitrogenase enzyme. Interaction between plants and microbes: Siderophores, Rhizosphere, Rhizoplane, Phyllosphere and Phylloplane. Taxonomy of Mycorrhizas and Actinorhiza, host fungus specificity, functional compatibility and the importance of mycorrhizae in agriculture, horticulture and forestry. Characteristics of carrier-based inoculants and strain selections. *Rhizobium*, *Azotobacter*, *Azospirillum*, Mycorrhiza, Phosphate solubilizing microorganisms, Cyanobacteria, and *Azolla*. Production technology and application. Mushroom cultivation and biogas production.	
UNIT II **HOST PARASITE INTERACTIONS**	**6**
Role of host exudates; process of pathogen entry; role of enzymes, hormones and toxins produced by pathogens in pathogenesis; deranged host metabolism.	

UNIT III **HOST RESISTANCE**	**9**
Passive and induced resistance; Phytotoxins and Phytoalexins; Hypersensitivity reaction. Protection, Plant quarantine, Eradication, Chemical control- Systemic fungicides, Antibiotics. Acquired resistance of fungicides, Biological Control of pathogens, Genetic methods for crop improvement and Integrated Pest Management.	
UNIT IV **PLANT PATHOLOGY**	**7**
Introduction to Plant disease, Disease triangle, and stages of disease development. **Etiology, symptoms and control measures of plant diseases-** a. Citrus canker (*Xanthomonas citrii*) b. Crown gall Disease (*Agrobacterium tumifaciens*) c. Damping off (*Pythium* spp.) d. Downy mildew of grapes (*Plasmopara viticola*) e. Wheat Rust (*Puccinia graminis*) f. Tikka disease of groundnut (*Cercospora* spp.) g. Red rot of sugar cane (*Colletotrichum falcatum*) h. Ergot of rye (*Claviceps purpurea*) i. Sandal spike j. Tobacco mosaic disease k. Citrus exocortis	
UNIT V **MICROBIAL INSECTICIDE**	**8**
Definition, selection, mode of action, methods of mass culture and production, advantages, limitation and quality control. Eg. *Bauveria bassiana*, NPV and *Bacillus thuringenesis*. Applications of Genetic Engineering in Agricultural Microbiology: Antisense RNA technology.	

NOTE: 6 hours of self-study assigned from the above units.

REFERENCES:

1. Mehrotra R. S. (1983). Plant pathology. Tata McGraw-Hill.
2. Pandey, B. P. (2001). Plant pathology (Pathogen and Plant disease). S. Chand Publishing.
3. Raychaudhuri, S. P. (1977). A manual of virus diseases of tropical plants. Macmillan Company of India Ltd.
4. Rangaswami G. (1973). Bacterial plant pathology. Tamil Nadu Agricultural University.
5. Subba Rao N. S. (1977). Soil microorganisms and plant growth (3rd ed. rev.enl). Oxford & IBH Pub.

BLUEPRINT

Code number: MB 8524
Title of the paper: AGRICULTURAL MICROBIOLOGY

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	15	23
II	6	12
III	9	12
IV	7	12
V	8	12
TOTAL	**45**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

CO1	Gain knowledge in the Intricacies of Plant-Microbe interactions (beneficial and harmful)
CO2	Have an in depth understanding of the Mechanisms of Biochemical changes in symbiotic and deranged metabolism in pathogenic associations
CO3	Apply the effectiveness of the agricultural-based microbial products from beneficial organisms for the growth of crops and control of plant pathogens
CO4	Compare and contrast the changes and effects of both positive and negative interactions for the exchange and uptake of nutrients
CO5	Exploit, apply and evaluate the activity of beneficial microbes in crop improvement and plant protection
CO6	Develop strategies for crop protection and harnessing the efficacy of microbes for better growth, yield and vigour of plants

PRACTICALS

MB 8P$_1$: MICROBIAL PHYSIOLOGY AND IMMUNOLOGY

88 Hours/22 Units

	MICROBIAL PHYSIOLOGY	
Sl NO	**EXPERIMENTS**	**Unit(s)**
1.	Determination of Growth – Bacterial Growth curve and generation time (Introduction of stress to monitor changes in bacterial growth).	1
2.	Quantitative estimation of biomolecules using different methods exploring diverse principles and applications involved.	
	a. Estimation of DNA.	1
	b. Estimation of RNA.	1
	c. Estimation of Proteins.	1
	d. Estimation of Reducing sugar.	1
3.	Isolation of Amylase producing organisms and estimation of its activity: using DNSA /ethylidene-pNP-G7.	1
4.	Determination of K_m and V_{max}.	1
5.	Saponification value of fat.	1
6.	Iodine number of fatty acids.	1
7.	Estimation of Phosphatase	1
8.	Estimation of Catalase activity.	1
	IMMUMOLOGY	
	EXPERIMENTS	**Unit(s)**
1.	Agglutination test- Blood grouping and WIDAL	2
2.	Precipitation tests (RIEP, CCIEP).	2
3.	Identification of *Staphylococcus aureus* by coagulase test.	2
4.	ELISA	1
5.	Determination of nonspecific resistance to bacteria.	2
6.	Determination of bactericidal activity of normal serum.	2

REFERENCES

1. Hudson, L., & Hay, F. C. (1980, January 1). *Practical Immunology*. Blackwell Science.
2. Plummer, D. T. (2001, February 1). *Introduction to Practical Biochemistry*.
3. Pommerville, J. C. (2004, January 1). *Alcamo's Fundamentals of Microbiology*. Jones & Bartlett Learning. Alexander J. Ninfa, 1998.
4. Sadasivam, S., & Manickam, A. (2007, January 1). *Biochemical Methods*.
5. Ninfa, A. J., Ballou, D. P., & Benore, M. (2009, May 26). *Fundamental Laboratory Approaches for Biochemistry and Biotechnology*. John Wiley & Sons.
6. Johnson, T. R., & Case, C. L. (2013, January 1). *Laboratory Experiments in Microbiology*. Benjamin-Cummings Publishing Company.

MB 8P$_2$: FOOD AND AGRICULTURAL MICROBIOLOGY

88 hours/22 units

FOOD MICROBIOLOGY		
SL. NO.	**EXPERIMENTS**	**UNIT(S)**
1.	Rapid platform tests, DMC and SPC of milk. RODAC (Replicate Organism Detection and Counting) plate method	2
2.	Rapid tests to detect the presence of common adulterants in food. (Milk and milk products, oils and fats, sweetening agents, food grains and spices)	1
3.	Detection and determination of anaerobic mesophilic spore formers from food. (*Clostridium perfringens*)	1
4.	Lactose estimation in milk	1
5.	Production of Yoghurt from starter cultures	1
6.	Role of Yeast and enzymes in baking	1
7.	Study of browning reactions in foods	1
8.	Study of ropiness in foods	1
9.	Production and detection of aflatoxins from spoilt foods	1
10.	Food preservation by salt, sugar and sodium benzoate	1
AGRICULTURAL MICROBIOLOGY		
SL. NO.	**EXPERIMENTS**	**UNIT(S)**
1	Isolation of fungi and determination of antagonistic activity of soil fungi.	2
2	Isolation of phosphate solubilizing bacteria and fungi.	2
3	Isolation of *Rhizobium* spp., and study of root nodules of legumes	1
4	Staining and identification of AMF propagules	1
5	Bioassay of Biofertilizers	1

6	Mushroom cultivation	1
7	Study of plant pathogens	1
8	Screening of siderophore producing bacteria.	2

REFERENCES:

1. Aneja, K. R. (2007). *Experiments in microbiology, plant pathology and biotechnology*. New Age International.
2. Cappuccino, J. G., & Sherman, N. (2013). *Microbiology: A Laboratory Manual*. Pearson Educacion.
3. Rajan, S., & Christy, R. S. (2018). *Experimental procedures in life sciences*. CBS Publishers & Distributors Pvt Limited, India.
4. Sharma, K. (2007). *Manual of Microbiology: Tools & Techniques*. Anshan Pub.
5. Singer, S. (2001). *Experiments in Applied Microbiology*. Academic Press.

Semester	III
Paper Code	**MB 9124**
Paper Title	**Recombinant DNA Technology**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE

This paper enables the students to understand the basic principles of recombinant DNA techniques and equip them with the skills required in designing transgenic systems and to create professionals who can use Genetic Engineering techniques in diverse fields.

UNIT I	**18**
a. Introduction to Recombinant DNA Technology **b. Tools in genetic engineering** DNA manipulative enzymes: Restriction endonucleases – Nomenclature, classification, enzyme catalysis and applications. DNA Ligase - Types, enzyme catalysis and ligation strategies. DNA modifying enzyme: Polynucleotidyl kinase, alkaline phosphatase and terminal nucleotidyltransferase.	6
c. Cloning Vectors Plasmids **(**pBR322, pUC-8, pGEM3Z and Ti plasmid) Bacteriophage (λ phage and M13 vectors) Cosmids, phagemids, expression vectors, shuttle vectors, BACs and YACs, Excretion Vectors and Animal viral vectors (Adeno virus and retro virus). Cloning and expression in bacteria and yeast.	12
UNIT II	**7**
a. Basic principles of gene cloning strategies. b. **Transformation techniques** $CaCl_2$ mediated Transformation, Micro projectile Bombardment, Microinjections, Electroporation, Liposome mediated transfer, and Agrobacterium-mediated transfer**.**	

UNIT III	**4**
Genomic and cDNA library construction and their applications	
UNIT IV	**7**
Analysis of gene and gene products a. **Direct methods** – Selection by Complementation or Nonsense separation and marker inactivation techniques.	2
b. **Indirect methods** – Restriction enzyme cleavage pattern, Hybridization techniques (Colony and Plaque hybridization), Blotting techniques, Chromosome walking, Detection of specific protein by invitro translation techniques, Immunological methods, Protein synthesis in mini cells and Maxi cells.	5
UNIT V	**18**
a. PCR – Gene amplification, Primer designing, optimization, variation in the PCR, and types of PCR.	4
b. DNA sequencing technology and its applications – Maxam Gilbert's method, Sanger, Coulsen's method, automated sequencing, next-generation sequencing. Applications of sequencing	3
c. DNA fingerprinting and its applications	2
d. DNA Microarrays – Types, features and their application in the study of gene expression	3
e. Chemical synthesis of oligonucleotides: Phosphodiesters, Phosphotriester, Phosphitetriester approaches, enzymatic synthesis of DNA and applications of synthetic oligonucleotides.	3
f. Site-directed Mutagenesis, Genome Editing (Crispr-cas, Zfn, Talen) and their applications	3
UNIT VI	6
Applications of gene cloning a. Transgenic systems b. Applications of gene cloning in Medicine (Gene therapy), Agriculture (Transgenic plants – Insecticide resistant and herbicide-resistant).	4
Ethical concerns and Safety of recombinant DNA technology a. Ethical, Legal, Social and Environmental issues related to rDNA technology. b. Restriction and regulation for the release of GMOs into Environment.	2

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

Sl. No.	References
1.	Brown, T. (2020). *Gene Cloning and DNA Analysis: An Introduction*. http://ci.nii.ac.jp/ncid/BA55279454
2.	Primrose, S. B., Twyman, R. M., & Old, B. (1980). *Principles of gene manipulation*. http://ci.nii.ac.jp/ncid/BA5542125X
3.	Glick, B. R., & Pasternak, J. (1995). Molecular biotechnology: principles and applications of recombinant DNA. *Choice Reviews Online*, *32*(08), 32–4487. https://doi.org/10.5860/choice.32-4487
4.	Kreuzer, H., & Massey, A. (2001). *Recombinant DNA and Biotechnology: A guide for students*. https://ci.nii.ac.jp/ncid/BA29092809
5.	Sambrook, J., Fritsch, E., & Maniatis, T. (2001). *Molecular Cloning: a Laboratory manual*. http://ci.nii.ac.jp/ncid/BB09365076
6.	*Winnaker E.L., 1987, From Gene to Clone: Introduction to Gene Technology, VCH Publications, Weinbem Federal Republic German*

BLUEPRINT

Code number: MB 9124

Title of the paper: RECOMBINANT DNA TECHNOLOGY

Chapter number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	18	21
II	07	8
III	04	6
IV	07	8
V	18	21
VI	06	7
Total	**60**	71
Maximum marks for the paper (Excluding bonus questions): **50**		

COURSE OUTCOMES:

At the end of the course, the students will be able to

CO1	Gain an understanding of the tools and processes used in rDNA technology.
CO2	Contrast different techniques used in analysis of gene and their expression.
CO3	Apply the techniques towards cloning genes in different biological systems.
CO4	Analyze enzymes used in recombinant DNA technology
CO5	Summarize applications of rDNA technology
CO6	Design a workflow to carry out rDNA technology experiment: Cloning, expression and down streaming.

DEPARTMENT OF MICROBIOLOGY

Semester	III
Paper Code	**MB 9224**
Paper Title	**Medical Microbiology**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE

Medical Microbiology seeks to empower students with knowledge and learning opportunities in the basic principles of medical microbiology and infectious disease. The ability to promote human health. It provides opportunities to develop informatics and diagnostic skills, including the use and interpretation of laboratory tests in the diagnosis of infectious diseases and use their knowledge in clinical research.

UNIT I	**15**
a. Introduction to Medical Microbiology. Infections, Types of infections, methods of transmission. b. Laboratory Management: - Safety in a microbiology laboratory. c. Quality control in Clinical microbiology: - Internal and External (NABL) d. Biomedical waste management, quantity, types of biomedical waste and waste treatment. e. Introduction to Human microbiome- Description of factors and processes that influence community assembly and composition. Importance with special reference to gut microbiota (in health and diseases). Faecal Transplantation f. Factors responsible for pathogenesis.	
UNIT II	**14**
Bacterial diseases List of diseases of various organ systems and their causative agents. The following diseases in detail with Culture, Signs Symptoms, mode of transmission, virulence, pathogenesis, laboratory diagnosis, prophylaxis and control. a. Respiratory Diseases: *Streptococcus pyogenes, Mycobacterium tuberculosis.* b. Gastrointestinal Diseases: *Salmonella typhi, Vibrio cholerae, Helicobacter pylori.*	

c. Skin: *Staphylococcus aureus, Clostridium tetani.* d. *Treponema pallidum.* e. *Pseudomonas aeruginosa.*	
UNIT III	**17**
Viral, Fungal and Parasitic diseases. **Viral diseases.** a. List of diseases of various organ systems and their causative agents. The following diseases in detail with Signs, Symptoms, mode of transmission, pathogenesis, laboratory diagnosis, prophylaxis and control; DNA viruses - Herpes, Hepatitis B virus. b. RNA viruses - Dengue, Zikka, H1N1, Corona. c. Viral zoonoses – Rabies. d. Oncogenic viruses. **Fungal diseases** a. Classification of medically important fungi. Brief description of each of the following types of mycoses and one representative disease to be studied with respect to transmission, symptoms, culture, laboratory diagnosis, pathogenesis, prevention and control. b. Cutaneous mycoses- Tinea pedis (Athlete's foot). c. Yeast -*Cryptococcus neoformans.* d. Yeast like - *Candida albicans.* e. Filamentous –*Aspergillus spp.* f. Dimorphic- *Histoplasma capsulatum.* **Parasitic diseases:** a. *Giardia lamblia,* b. *Plasmodium spp.,* (Any emerging infection to be included)	
UNIT IV	**14**
a. Nosocomial infections: Microbiology of hospital infections, common type of infections, diagnosis, and control of infections. b. Classification of antimicrobial agents and Mechanism of Action. **Antibacterial agents**: Penicillin, Polymyxin, Tetracycline, Chloramphenicol, Sulphonamides. **Antifungal agents**: Echinocandins- Caspofungin, Azoles, Polyenes - Griseofulvin, Nystatin , Amphotericin B, Flucytosine **Antiviral agents**: Zidovudine, Acyclovir, Remdesivir, **Antiparasitic agents:** Chloroquine, Metronidazole.	

Antibiotic resistance: MDR, XDR, MRSA, AMR-TB, ESBLS NDM-1 c. Methods of testing drug sensitivity. d. An overview of Clinical Trials. e. An overview of Epidemiology and public health: definition, agencies, public health surveillance, Remote sensing and geographic information systems, calculate rates of incidence, prevalence, morbidity and mortality.	

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

1. Baijayantimala Mishra (2022) *Textbook of Medical Virology***.** 2nd Edition. India. CBS Publishers.
2. David Greenwood, Richard C.B. Slack and John. F. Peutherer (2008). *Medical Microbiology*.7th Edition, New Delhi. Elsevier India Private Ltd.
3. Goering (2018). *Mims' Medical Microbiology and Immunology*, International, 6th Edition.
4. Jawetz, Melnick and Adelbergs (2019). *Medical Microbiology*. 28th Edition. USA. McGraw Hill Companies.
5. Kenneth Ryan , Nafees Ahmad , J. Andrew Alspaugh , W. Lawrence Drew , Michael Lagunoff , Paul Pottinger L. Barth Reller , Megan Reller (2018) *Sherris Medical Microbiology*, 7th Edition McGraw Hill.
6. Leonard C. Norkin (2010) *Virology: Molecular Biology and Pathogenesis*. 1st Edition. India. American Society for Microbiology.
7. Linda Sherwood, Christopher J. Woolverton, Lansing M. Prescott, and Joanne M. Willey (2011). *Prescott's Microbiology*.7th Edition. New York: McGraw-Hill.
8. Michael Barer ,W L Irving (2018). *Medical Microbiology* 19thh Edition.
9. Patricia. M.Tille (2015). *Bailey and Scotts Diagnostic Microbiology.*14th Edition. Mosby.
10. Patrick R. Murray, Ken s.Rosenthal, Michael A. Pfaller (2015). Medical Microbiology.8th Edition. India. Elsevier.
11. Reba Kanungo(2020).*Ananthanarayan and Paniker Text book of Microbiology. 11*th Edition. Universities Press.
12. W.W.W. Topley and Sir Graham S.Wilson (2006) *Topley & Wilson's Microbiology and Microbial Infections.*10TH Edition. London. Hodder and Arnold.
13. Yi-Wei Tang (2022) *Molecular Medical Microbiology*. 3rd Edition. Elsevier.
14. Villanova, PA; NCCLS: 2002.National Committee for Clinical Laboratory Standards (Now Clinical and Laboratory standards Institute, CLSI). Performance standards antimicrobial susceptibility testing; 12th information supplement (M100-S1).
15. Villanova, PA: NCCLS, 1997.National Committee for Clinical Laboratory Standards (now Clinical and Laboratory Standards Institute, CLSI). Methods for dilution antimicrobial susceptibility testing for bacteria that grows aerobically. Approved Standards M7-A4.

BLUEPRINT

Code number: MB 9224
Title of the paper: Medical Microbiology

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
I	15	18
II	14	16
III	17	21
IV	14	16
TOTAL	**60**	**71**
Maximum marks for the paper (Excluding bonus questions) = 50		

COURSE OUTCOMES

At the end of the Course, the student will be able to

CO1	a. Understand and gain knowledge of the workflow inside the clinical microbiology laboratory. b. Describe the importance of pathogenic microorganisms in human diseases and the various parameters of assessment of their severity and methods of diagnosis.
CO2	a. Learn molecular mechanisms of pathogenesis. b. Compare and contrast the similarities and differences between different pathogens and address the issues related to transmission and prevention of the diseases.
CO3	a. Assess and interpret antibiotic sensitivity tests. b. Highlight the importance and significance of the gut microbiome and antimicrobial resistance and control measures.
CO4	a. Select appropriate procedures for specimen collection, isolation and identification of pathogens. b. Interpret the possible suggested preventive and treatment methods for human pathogens.
CO5	a. Develop knowledge and skills in writing clinical research. b. Assess and interpret strategies for prevention and protection against diseases.

DEPARTMENT OF MICROBIOLOGY

Semester	III
Paper Code	**MB 9324**
Paper Title	**INDUSTRIAL MICROBIOLOGY**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

OBJECTIVE

Industrial microbiology provides an understanding of the processes involved in the production of variety of biological products; including biopharmaceuticals, therapeutics, diagnostics, etc. with the help of microorganisms, the course discusses variety of aspects of fermentation ranging from the equipment utilised, types of microorganisms, genetic modifications of these organisms required, to standardization of the processes for a large scale production to subsequent downstream processing of the products. It also offers some practical experience of production at a laboratory scale.

UNIT I	**1**
a. Concepts and scope of fermentation technology	
UNIT II	**7**
a. Basic design and function of a fermenter. b. Types of fermenters: stirred tank fermenters, tubular fermenters, tower fermenters, air-lift fermenters, membrane bioreactors, photo bioreactors, disposable fermenters, fluidized bed fermenters. c. Solid-state fermenters: tray fermenters, drum fermenters	
UNIT III	**11**
a. Media sterilization, sterilization of fermenter, sterilization of air supply. b. Aseptic inoculation methods, sampling methods, monitoring and control devices. c. Fermentation media: media formulations, sources of carbon, nitrogen, vitamins and minerals. d. Role of buffers, precursors, inhibitors, inducers and antifoam agents. e. Development of inoculum for bacterial, fungal, and actinomycetes. f. Substrate for solid state fermentation g. Power requirement, Oxygen transfer kinetics.	

h. Concepts of Newtonian and non-Newtonian fluids, plastic fluids, apparent viscosities	
UNIT IV	**6**
a. Microbial growth kinetics: Batch, Continuous and Fed-Batch culture.	
UNIT V	**11**
a. Isolation, preservation and improvement of industrial microorganisms: Isolation methods, screening methods, preservation techniques, strain improvement, protoplast fusion, parasexual cycle and recombinant DNA techniques. b. Immobilization of enzymes and cells: methods, advantages and applications	
UNIT VI	**8**
a. Scale-up of fermentation process: parameters used in scale-up and problems associated with scale-up. b. Downstream processing: objectives and criteria, foam separation, precipitation methods, filtration devices and filter aids. c. Industrial scale centrifugation and cell disruption methods, liquid-liquid extraction, solvent recovery, chromatography, microfiltration, ultrafiltration, drying devices, crystallization and whole broth processing.	
UNIT VII **MICROBIAL TECHNOLOGY**	**16**
a. Production of: alcohol-beer and ethanol; Organic acids- citric acid; Amino acids- glutamic acid; Antibiotics- penicillin; Vitamins- Vitamin B12; Enzymes- protease; Biopolymers-: xanthan gum b. Production of recombinant proteins- human insulin, interferon; Recombinant vaccine production - Hepatitis B vaccine; melanin biosynthesis in *E.coli*; Chymosin production in *E.coli* and yeast. c. Biosafety regulation of products, microbial products and biosafety concerns – individual, society, national and international, biosafety regulations in laboratories, handling of recombinant products. d. An overview of Pharmaceutical Microbiology. e. IPR - Patents, licensing, copyrights and trademarks	

NOTE: 8 hours of self-study assigned from the above units

REFERENCES:

1. Casida L. E. (1968). Industrial microbiology. Wiley.
2. Crueger W. Crueger A. & Brock T. D. (1984). Biotechnology: a textbook of industrial microbiology. Sinauer Associates; Science Tech.
3. Flickinger M. C. & Drew S. W. (1999). The encyclopedia of bioprocess technology: fermentation biocatalysis and bioseparation. Wiley.
4. Peppler H. J. & Perlman D. (2014). Microbial technology: fermentation technology (2nd ed.).
5. Stanbury, P.F., Whitaker, A. and Hall, S.J. (1995). Second Edition, Principles of fermentation technology.
6. Pirt S. J. (19851975). Principles of microbe and cell cultivation. Blackwell Scientific.

BLUE PRINT

Code number: MB 9324
Title of the Paper: INDUSTRIAL MICROBIOLOGY

Chapter/Unit Number	**Number of Hours**	**Total marks for which the questions are to be asked (including bonus questions)**
I	1	2
II	7	8
III	11	13
IV	6	7
V	11	13
VI	8	9
VII	16	19
Total Marks	60	71
Maximum marks for the paper (Excluding bonus questions) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

CO1	Gain an insight into the role of microbes in Industrial production of valuable products
CO2	Have an in-depth knowledge of the process parameters and vital requirements suited for microbial growth to enhance product production.
CO3	Standardise methods for production of products in the laboratory scale.
CO4	Compare the design of bioreactors and the processes necessary for industrial use.
CO5	Evaluate the effectiveness of microbial strains.
CO6	Develop concepts to design bioreactors and exploit the suitable strains of microorganisms for product formulation.

DEPARTMENT OF MICROBIOLOGY

Semester	III
Paper Code	**MB 9424**
Paper Title	**BIOSTATISTICS AND BIOINFORMATICS**
Number of teaching hours per week	4
Total number of teaching hours per semester	60
Number of credits	4

OBJECTIVE

This paper aims at gaining knowledge on the basic concepts and techniques in the field of biostatistics and bioinformatics. It aims to facilitate students with the necessary tools to examine, understand and conduct statistically valid research. It also enables students to understand and appreciate the pivotal role played by bioinformatics in advancing our knowledge of the living world.

PART A – BIOSTATISTICS	
UNIT I	**8**
Samples and Populations, Variables in Biology, Sampling methods.	2
Frequency distribution, Graphical representation of data: histogram, frequency curve and ogives	2
Introduction to statistics in R, Python	1
Measures of Central tendency: Mean, Median and Mode. Measures of dispersion: Range, Mean deviation, Standard deviation, Standard error, Variance.	3
UNIT II	**12**
Probability: Addition and multiplication rules. Bayes' theorem	1
Probability distributions: Binomial, Poisson and Normal. Student "t" distribution.	2
Point estimation and interval estimation. Estimating the population mean: known and unknown.	1

Null and alternate hypotheses	1
Parametric and non-parametric tests	1
t-test: one-tailed and two-tailed	1
ANOVA: one way and two-way Least significant difference (LSD)	2
Wilcoxon Rank Sum Test	1
Wilcoxon Signed Rank test	1
Chi-square test: test of independence, goodness of fit and homogeneity	1
UNIT III	**6**
Correlation: Definition, types, and measurements of correlation.	2
Regression analysis: Equation, estimation of unknown value from known value.	2
Randomization – bootstrapping	2
UNIT IV	**4**
Hands-on use of Graph Pad Prism. Brief introduction to JMP, Tableau.	
PART B – BIOINFORMATICS	
UNIT I	**9**
Databases: Introduction to data bases-Relational databases- Oracle, SQL, Database generation, Sequence databases- NCBI – BLAST Resources- Human Genome Project (HGP), Microbial genomes, structural databases- protein data Bank (PDB), Organization of databases, Navigation through databases.	3
PubChem, Zinc database, MetaCyc.	2
Tools For Data Bank - Pairwise Alignment - Needleman and Wusch Algorighm – Smith Waterman - Multiple Alignment - Clustral - Pras - Blast - Fast, Algorithms to analyse Sequence Data - Pdb, Cambridge Structure Data Base	4
UNIT II	**7**
Principles behind computational analysis, Sequence analysis, sequence	4

alignment and phylogenetic analysis with reference to nucleic acids, identification of ORF'S. Sequence analysis, sequence alignment, phylogenetic analysis with reference to proteins, Selection analysis	 3
UNIT III	**7**
Protein Sequence Analysis - Introduction - Sequence Data Banks - Wbrf – Pir – Swissport - Databases, Data Mining - Algorithms of Proteomics And Its Applications – Protein - Modelling, Introduction and Navigation in Alphafold protein structure database. Expression Profiling - Protein - Protein Interaction - Protein Modifications. Automation - Nucleic Acid Data Bank – Embl Nucleotide Sequence Data Bank - Aids Virus Sequence Data Bank - Rna Data BanK 'Next Gen' Sequence Analysis (RNA-Seq) / Metagenomics	3 2 2
UNIT IV	**7**
Introduction to Hidden Markov Models Analysis and interpretation of results: 2D Electrophoresis, HPLC, Mass Spectrometry, Mass Fingerprinting	2 5

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

PART A – BIOSTATISTICS

1. Armstrong, R.A. and Hilton, A.C. (2011) *Statistical Analysis in Microbiology: Statnotes*. Wiley Blackwell Pub.
2. Borman, D. (2018) *Statistics 101: From Data Analysis and predictive modeling to measuring distribution and determining probability, Your Essential Guide to Statistics*. Avon, MA: Adams Media.
3. Bulmer, M.G. (1979) *Principles of statistics*. New York: Dover publ.
4. DeGroot, M.H. and Schervish, M.J. (2019) *Probability and statistics*. Hoboken, NJ: Pearson Education, Inc.
5. Freedman, D., Pisani, R. and Purves, R. (2018) *Statistics*. New Delhi etc.: Viva Books.
6. Griffiths, D. (2009) *Head first statistics*. Farnham: O'Reilly.
7. Krishnan, V. (2011) *Statistics for beginners*.
8. Paulson, D.S. (2008) *Biostatistics and Microbiology: A Survival Manual*. Springer Science & Business Media.

PART B – BIOINFORMATICS

1. Baxevanis, A. D., Bader, G. D., & Wishart, D. S. (Eds.). (2020). *Bioinformatics*. John Wiley & Sons.
2. Higgins, D., & Taylor, W. (Eds.). (2000). *Bioinformatics: Sequence, Structure and Databanks: A Practical Approach* (Vol. 236). OUP Oxford.
3. Attwood, T. K., & Parry-Smith, D. J. (2002). Introduction to bioinformatics.
4. Taxali, R. K. (1991). *Dbase III Plus Made Simple: With DBASE IV and FoxBASE*. Tata McGraw-Hill.
5. Shaik, N. A., Hakeem, K. R., Banaganapalli, B., & Elango, R. (2019). Essentials of Bioinformatics, Volume I.
6. Barnes, M. R., & Gray, I. C. (Eds.). (2003). *Bioinformatics for geneticists*. John Wiley & Sons.
7. Augen, J. (2004). *Bioinformatics in the post-genomic era: Genome, transcriptome, proteome, and information-based medicine*. Addison-Wesley Professional.
8. Ewens, W. J., & Grant, G. R. (2005). *Statistical methods in bioinformatics: an introduction* (Vol. 15). New York: Springer.
9. Luo, J. (2014). Teaching the ABCs of bioinformatics: a brief introduction to the Applied Bioinformatics Course. *Briefings in bioinformatics*, *15*(6), 1004-1013.

BLUEPRINT

Code number: MB 9424
Title of the paper: BIOSTATISTICS AND BIOINFORMATICS

Chapter/ Unit number	Number of hours	Total marks for which the questions are to be asked (including bonus questions)
Biostatistics		
I	8	9
II	12	14
III	6	7
IV	4	5
Bioinformatics		
I	9	11
II	7	9
III	7	8
IV	7	8
TOTAL	**60**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

PART A – BIOSTATISTICS

CO1	Apply the knowledge of the basic concepts of Biostatistics
CO2	Distinguish different hypotheses in research papers
CO3	Compile, analyze and interpret different types of datasets.
CO4	Understand the basic functioning of R. Execute the knowledge in practical demonstration of various concepts in GraphPad Prism.

PART B – BIOINFORMATICS

CO1	Apply the knowledge of the basic concepts of Bioinformatics
CO2	Execute the knowledge in the practical demonstration of various bioinformatic tools and databases
CO3	Design and conduct experiments in applied Bioinformatics.
CO4	Analyze different datasets from distinct genomic and protein databases to appreciate various bioinformatic softwares.
CO5	Compile and interpret the different types of datasets and models.

DEPARTMENT OF MICROBIOLOGY

Semester	III
Paper Code	**MB 9524**
Paper Title	**ENVIRONMENTAL MICROBIOLOGY**
Number of teaching hours per week	3
Total number of teaching hours per semester	45
Number of credits	3

OBJECTIVE

Understanding the intricate relationship between microorganisms and the environment. Studying the effect of microbial processes on environment and human life. Utilization of microbial processes for the remediation and protection of the environment.

UNIT I	
Microbial ecology and microbiome biology Microbial interactions, microbial evolution Microbiome study- plant microbiome, effect of environment on human microbiome Environmental metagenomics	**7** 3 4
UNIT II	
Air Microbiology **Air borne diseases and control measures.** Bacterial- Pertussis, Meningitis, Diphtheria, Pneumonia, Pneumonic plague, Psittacosis Fungal- Coccidioidomycosis, Athlete's foot; Viral- Influenza, Measles, Chickenpox, Mumps, Cold and flu, Small pox, Cow pox, Monkey pox Actinomycetes – Actinomycosis, Madura foot Sick building syndrome. **Aeroallergens**- pollen, fungal spores, identification of pollen and spores – pollen calendar. **Air samplers-**Anderson's sampler, Cascade Impactor, Hirst trap, Burkard sampler, Rotorod, vertical cylinder trap, slit sampler, types of impingers. **CO_2 management** - Enzymatic Carbon capture utilization	**7** 2 2 3
UNIT III	
Aquatic and Sanitary Microbiology Aquatic habitats- surface, subsurface and marine habitats, zonation of water ecosystems.	**15** 3

Water pollution-Ground water and surface water contamination – Eutrophication, Acid rain **Indicators of water pollution and testing procedures-** Microbial indicators- fecal sterols-MPN for fecal coliforms, Membrane filtration methods, Immunomagnetic separation, Sequencing techniques, FISH. **Remedial measures** Ground water treatment: Containment – Chemical modification – Immobilization – volatilization – pump and treat methods **Sewage treatment**: Types and composition of sewage; Preliminary, Primary, Secondary treatment, and Tertiary treatment. 1. Sludge treatment, anaerobic digestion and value-added products. Effluent Disinfection and storage. 2. Biological Treatment of Industrial effluents – Textile industry, Paper industry, Leather and tanning industry, Petrochemical industry, Food and Dairy industry, Soaps and detergent industry. 3. Municipal water treatment **Water borne pathogens, diseases and control measures** Bacterial- Shigella, *E. coli*, Campylobacter, Legionella; Protozoan- Cryptosporidium, Ascaris, Tape worm, Trematodes Viral-Enterovirus, Adenovirus, Rota virus **BIS for Packaged Drinking water, ISI standard for potable water**	3 2 4 2 1
UNIT IV	
Soil microbiology Role of microorganisms in complex organic matter decomposition (cellulose, hemi cellulose, lignin). **Solid waste management:** Composting, vermicomposting and sanitary landfill, incineration. **Metallophilic bacteria:** Bioleaching of ore and metal corrosion, Bioaccumulation **Biodegradation of xenobiotics:** PCBs, plastics. **Biodeterioration of paper and textiles**	**10** 2 4 4
UNIT V	
Bioremediation Approaches to bioremediation- in-situ and ex-situ. Bio-stimulation, bioaugmentation and biotransformation. Bioremediation of various ecosystems- contaminated soil, marine oil spills, bioremediation of air pollution. Phytoremediation. Testing for biodegradability, efficacy testing, side-effect testing. **Biosensors-types and applications**	**6** 2 3 1

NOTE: 8 hours of self-study assigned from the above units.

REFERENCES:

1. Atlas, R. M. (1998). Microbial ecology: Fundamentals and Applications. Pearson Education India.
2. Bioleaching: metal solubilization by microorganisms, Klaus Bosecker, FEMS Microbiology Reviews. Volume 20, Issues 3–4, July 1997, Pages 591-604
3. Indian Standard, DRINKING WATER — SPECIFICATION; IS 10500 : 2012, BIS 2012
4. Lenski R. E. (2017). Experimental evolution and the dynamics of adaptation and genome evolution in microbial populations. The ISME journal, 11(10), 2181–2194. https://doi.org/10.1038/ismej.2017.69
5. Mylona, P., Pawlowski, K., & Bisseling, T. (1995). Symbiotic Nitrogen Fixation. The Plant cell, 7(7), 869–885. https://doi.org/10.1105/tpc.7.7.869
6. Nidoni P (2017). Incineration process for solid waste management and effective utilization of by products. International Research Journal of Engineering and Technology (IRJET). 4,12 e-ISSN: 2395-0056.
7. On- farm composting methods, R.V Mishra, R.N.Roy, H. Hiraoka.
8. Pepper, I. L., Gerba, C. P., & Gentry, T. J. (2015). Environmental Microbiology.
9. Schlößer, D. (1995). G. Bitton, Wastewater Microbiology. Wiley-Liss. ISBN: 0-471-30985-0. Journal of Basic Microbiology, 35(4), 216. https://doi.org/10.1002/jobm.3620350403
10. Wei, X., Lyu, S., Yu, Y., Wang, Z., Liu, H., Pan, D., & Chen, J. (2017). Phylloremediation of Air Pollutants: Exploiting the Potential of Plant Leaves and Leaf-Associated Microbes. Frontiers in plant science, 8, 1318. https://doi.org/10.3389/fpls.2017.01318 20, Issues 3–4, July 1997, Pages 591-604

BLUEPRINT

Code number: MB 9524

Title of the paper: ENVIRONMENTAL MICROBIOLOGY

Chapter/ Unit number	Number of hrs	Total marks for which the questions are to be asked (including bonus questions)
I	7	11
II	6	9
III	15	24
IV	10	16
V	7	11
TOTAL	**45**	**71**
Maximum marks for the paper (Excluding bonus question) = 50		

COURSE OUTCOMES

At the end of the Course, the Student will be able to

CO1	Appreciate various microbial environmental niches.
CO2	Learn microbial interactions, adaptations and their influence on the environment.
CO3	Perform experiments to study microorganisms living in varied environments and to assess different physical and chemical environmental parameters.
CO4	Appreciate the role of microorganisms in treatment of different kinds of wastes and bioremediation.
CO5	Assess the positive and negative impact of microorganisms on the environment and evaluate environmental problems on a global scale.
CO6	Innovate approaches in environmental problem solving and assert their roles towards the environment as responsible citizens.

PRACTICALS

MB 9P$_1$: RECOMBINANT DNA TECHNOLOGY AND MEDICAL MICROBIOLOGY

88hours/22 Units

Sl No.	EXPERIMENTS	UNIT(S)
1.	Collection and processing of clinical samples for microbiological examination.	1
2.	Isolation and culture of medically important Anaerobes.	1
3.	Differential Staining techniques: AFB, Leishman's.	1
4.	Lab Study of various stages of malarial parasite.	1
5.	Study diseases with the help of photographs -Corona, Ebola.	1
6.	Institute Visit- Observation of a Clinical Microbiology Laboratory.	3
7.	Antimicrobial susceptibility tests.	1
8.	$CaCl_2$ mediated gene transfer.	2
9.	Isolation of plasmid DNA by column chromatography.	1
10.	Restriction digestion of isolated DNA (single and double digestion).	1
11.	DNA ligation	1
12.	DNA amplification by PCR.	1
13.	Gene elution.	1
14.	Expression of cloned genes in *E. coli.*	2
15.	Purification of proteins by affinity chromatography.	1
16.	RNA isolation	1
17.	Southern blotting	1
18.	Western blotting	1

MB9P$_2$: INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY

88 hours/22 units

INDUSTRIAL MICROBIOLOGY		
Sl. No.	**EXPERIMENTS**	**UNIT(S)**
1	Screening and isolation of industrially important microorganisms (Enzyme - protease, and antibiotics) and their preservation.	2
2	Production of protease (SSF) and its estimation.	2
3	Batch production and estimation of citric acid.	1
4	Immobilization of cells by alginate method.	2
5	Isolation of protoplast from bacteria	1
6	Clarification of banana juice using pectinase.	2
7	Isolation of PHB producers and extraction of PHB.	2
ENVIRONMENTAL MICROBIOLOGY		
Sl. No.	**EXPERIMENTS**	**UNIT(S)**
1	Study of air samplers	1
2	Study of airborne microorganisms.	2
3	Determination of biological oxygen demand.	2
4	Determination of COD.	1
5	Chemical and Bacterial analysis of water- determination of TDS, TSS, MPN	1
6	Estimation of organic carbon in soil	1
7	Isolation of methanogens	2
	Industrial visit	

REFERENCES:

1. James G. Cappuccino and Natalie Sherman. Microbiology: A Laboratory Manual.
2. Kanika Sharma. Manual of Microbiology: Tools and Techniques.
3. Robert S. Burlage, Ronald Atlas, David Stahl, Gill Geesey, Gary Sayler, 1998. Techniques in Microbial Ecology, Oxford University Press. N.Y.
4. Kc, S., Upadhyaya, J. S., Joshi, D. R., Lekhak, B., Chaudhary, D. K., Pant, B. R., Bajgai, T. R., Dhital, R., Khanal, S., Koirala, N., & Raghavan, V. (2020). Production,

Characterization, and Industrial Application of Pectinase Enzyme Isolated from Fungal Strains. Fermentation, 6(2), 59. https://doi.org/10.3390/fermentation6020059

5. Rawte, T., & Mavinkurve, S. (2002). A rapid hypochlorite method for extraction of polyhydroxy alkanoates from bacterial cells. Indian journal of experimental biology, 40(8), 924–929.
6. Arogundade, F. Q., & Lawal, R. A. (2023). Screening and isolation of protease-producing bacteria from wastewater samples in Obafemi Awolowo University (OAU) Campus, Ile-Ife, Nigeria. bioRxiv (Cold Spring Harbor Laboratory). https://doi.org/10.1101/2023.07.09.548249

DEPARTMENT OF MICROBIOLOGY

Semester	IV
Paper Code	**MB 0424**
Paper Title	**DISSERTATION**
Total number of hours	360
Number of credits	12