

## MICROBIOLOGY

### M.Sc. Syllabus

Paper	Paper Code	Paper Name	Credits	Full Marks
<b>First Semester</b>				
Paper - 1	MIC-PG-C101	Microbial Diversity	4 Credits	100 Marks
Paper - 2	MIC-PG-C102	Microbial Biochemistry	4 Credits	100 Marks
Paper - 3	MIC-PG-C103	Microbial Physiology	4 Credits	100 Marks
Paper - 4	MIC-PG-C104	Laboratory Course-I	4 Credits	100 Marks
		National Service*	Non-credit	
<b>Second Semester</b>				
Paper - 5	MIC-PG-O201	Instrumentation and Bioinformatics	4 Credits	100 Marks
Paper - 6	MIC-PG-C202	Microbial genetics and Molecular Biology	4 Credits	100 Marks
Paper - 7	MIC-PG-C203	Clinical Microbiology	4 Credits	100 Marks
Paper - 8	MIC-PG-C204	Laboratory Course-II	4 Credits	100 Marks
<b>Third Semester</b>				
Paper - 9	MIC-PG-C301	Agricultural and Industrial Microbiology	4 Credits	100 Marks
Paper - 10	MIC-PG-C302	Environmental Microbiology	4 Credits	100 Marks
Paper - 11	MIC-PG-O303	Immunology	4 Credits	100 Marks
Paper - 12	MIC-PG-C304	Laboratory Course –III	4 Credits	100 Marks
<b>Fourth Semester</b>				
Paper – 13	MIC-PG-C401	Molecular Virology	4 Credits	100 Marks
Paper - 14	MIC-PG-C402	Food Microbiology	4 Credits	100 Marks
Paper - 15	MIC-PG-C403	Laboratory Course –IV	4 Credits	100 Marks
Paper - 16	MIC-PG-C404	Dissertation	4 Credits	100 Marks

\* One compulsory audit paper is called “National Service”. The National Service shall be compulsory for all Master students of our Department. It is exempted only for NSS volunteers who have completed 120 hours of service. The students shall complete the requirements of “National Service” by doing some service in their own villages, towns, etc. for a period of 30 days during the winter vacation between I and II semesters. The reports of such service shall be evaluated by the Department and adjudged “Satisfactory” or “Not Satisfactory”. If the report is “Not Satisfactory” the student will not be eligible for the degree.

## FIRST SEMESTER

### Paper -1: MIC-PG-C101: Microbial Diversity

4 Credits

#### Unit I: Introduction to Microbiology

History and scope of Microbiology: Discovery of Microorganism, Conflict over spontaneous generation. General introduction and overview of Microbial Evolution and Diversity. Microbial Taxonomy: General introduction and overview of Taxonomic ranks, Classification system Structural and functional differences between prokaryotic and eukaryotic cells.

#### Unit II: Bacteria

General characteristics of Proteobacteria. General characteristics of Gram Positive. Actinobacteria. Cyanobacteria, Prochlorophytes, *Chlamydia*. *Planctomyces*. The Verrucomicrobia. The Flavobacteria. The Cytophaga Group. Green sulfur bacteria. The Spirochaetes. *Deinococci*. The green non-sulfur bacteria. Hyperthermophilic bacteria. *Nitrospira* and *Deferribacter*.

#### Unit III: Archaea, Fungi and Protozoa

Archaea: General account of habitat and physiology of Euryarchaeota (Halophilic, Methanogen, *Thermoplasmatales*, *Thermococcales* and *Methanopyrus*, *Archaeoglobales*, *Nanoarchaeum* and *Aciduliprofundum*) and Crenarchaeota (Hyperthermophiles and Non- Hyperthermophiles). Mycology: Brief about classification, morphology, reproduction and economic importance of Fungi. Overview of Protozoa

#### Unit IV: Viruses

General characteristics and classification system of viruses. Isolation and cultivation of viruses. Viral multiplication and replication strategies for bacteriophages, DNA viruses (Herpesviruses, Poxviruses, Adenoviruses) RNA Viruses (Poliovirus, coronavirus, influenza, rabies and Reoviruses), Viruses that employ reverse transcriptase (Retroviruses, Hepadnavirus). Introduction to Giant Viruses, disease caused by them and the implication of their discovery on evolutionary tree.

#### Reading List

1. Carter, J. and Saunders, V. 2007. *Virology: Principles and Applications*. 1<sup>st</sup> edition. Wiley.
2. Garrett, R. A. and Hans-Peter Klenk, H-P.2007. *Archaea: Evolution, Physiology, and Molecular Biology*. 1<sup>st</sup> edition, Wiley-Blackwell.
3. Garrity, G.M. et al. 2005. *Bergey's Manual of Systematic Bacteriology*. 2<sup>nd</sup> edition, Springer.
4. Kavanagh, K.2005. *Fungi: Biology and Applications*, 1<sup>st</sup> edition, Wiley.
5. Madigan, M. T., Martinko, J. M., Dunlap, P. V. Clark, D. P. 2009. *Brock Biology of Microorganisms*. Twelfth edition, Pearson Education Inc, Pearson Benjamin Cummings, San Francisco.
6. Mehrotra, R.S. and Aneja, K. R. 1990. *An introduction to Mycology*. New Age International Publishers.
7. Willey, J. M., Sherwood, L. M. and Woolverton, C.J. 2008. *Prescott, Harley and Klein's Microbiology*. 7<sup>th</sup> edition. Mc-Graw Hill Companies Inc. New Jersey.

**Paper - 2: MIC-PG-C102: Microbial Biochemistry****4 Credits****Unit I: Biomolecules I**

Buffers and pH, Henderson Hasselbach equations; covalent and weak bonds (Hydrogen bond; van der Waals forces; hydrophobic interactions). Carbohydrate chemistry: classification and biochemistry of carbohydrates. Lipid Chemistry: Classification, properties and structure of lipids with emphasis on membrane lipids of archaebacterial and mycobacterium; Brief account of application of membrane lipids in classification of bacteria

**Unit II: Biomolecules II**

Proteins: Introduction to Amino acids chemistry and Classification and properties; Brief account of Peptide bond, Protein structure; Protein characterization and functional analysis. Protein degradation, Protein sequencing.

**Unit III: Enzymology**

Introduction, classification of enzymes, kinetics, enzyme inhibition and inhibitors. Allosteric enzymes and their regulation; Specific mechanisms of enzyme catalysis – serine proteases, ribonucleases, triose phosphate isomerase, lysozyme, lactate and alcohol dehydrogenases.

**Unit IV: DNA replication, recombination and repair**

Nucleic acids: Structural features and chemistry of nucleic acid. DNA replication. Homologous and site-specific recombination, DNA damage and repair.

**Reading List**

1. Benfield, Rosalie. 2009. *Biochemistry*. 1st ed. Chandni Chowk, Delhi: Global Media.
2. Nelson, D. L. and Cox, M.M. 2008. *Lehninger's Principles of Biochemistry*. 5<sup>th</sup> edition. W.H. Freeman
3. Pelley, John W., and Edward F. Goljan 2007. *Biochemistry*. Philadelphia, PA: Mosby Elsevier. Print.
4. Powar, C. B, and G. R Chatwal. 2008. *Biochemistry*. New Delhi: Himalaya Pub. House.
5. Stryer, L. 1988. *Biochemistry*. 3<sup>rd</sup> edition, W. H. Freeman & Co.
6. Voet, D. and Voet, J.G. 1995. *Biochemistry*. Wiley.
7. Wilson, K. and Walker, J. 2010. *Principles and Techniques of Biochemistry and Molecular Biology*. 7<sup>th</sup> edition, Cambridge University Press.

**Paper - 3: MIC-PG-C103: Microbial Physiology****4 Credit****Unit I: Bioenergetics and membrane biology**

Introduction to the Principles of bioenergetics, entropy, enthalpy, redox reactions in biological systems and redox potentials. Plasma Membrane: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active and passive transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes

**Unit II: Metabolism of carbon compounds**

Embden-Meyerhof pathway, Krebs cycle and reverse TCA cycle, glyoxylate pathway, gluconeogenesis; fermentation of carbohydrates- lactic, alcoholic, acetic acid fermentations; Methylo trophy and methanotrophy, Degradation and utilization of cellulose and starch. Lipid metabolism – biosynthesis and oxidation of fatty acid oxidation. Introduction to Metabolomics.

### **Unit III: Phosphorylation and metabolism of inorganic compounds**

Oxidative phosphorylation: Electron carrier molecules, Electron transport chain; coupling of ADP and Pi; Photosynthesis: Brief account of photosynthetic and accessory pigments: chlorophyll, bacteriochlorophyll, carotenoids, and phycobiliproteins. Oxygenic and anoxygenic photosynthesis, autotrophic generation of ATP; Bacteriorhodopsin; Fixation of CO<sub>2</sub> (Calvin cycle). Chemosynthesis and anaerobic respiration.

### **Unit IV: Microbial development**

Peptidoglycan synthesis, bacterial cell division, sporulation, differentiation, stress response.

### **Reading List**

1. Chaudhary, Vikas. 2008. *Microbial Physiology and Metabolism*. New Delhi, India: Navyug Publishers & Distributors.
2. Madigan, T. M., Martinko, J.M. and Parker, J. 2008. *Brock's Biology of Microorganisms*. 12<sup>th</sup> edition, Prentice Hall College Div.
3. Moat, A.G. and Foster, J.W. 2002. *Microbial Physiology*. 4<sup>th</sup> edition, Wiley-Liss.
4. Nelson, D. L. and Cox, M.M. 2008. *Lehninger's Principles of Biochemistry*. 5<sup>th</sup> edition. W.H. Freeman
5. Poole, Robert K. 2012. *Advances in Microbial Physiology*. Amsterdam: Elsevier/Academic Press.
6. Voet, D. and Voet, J.G. 1995. *Biochemistry*. Wiley.
7. Wilson, K. and Walker, J. 2008. *Practical Biochemistry - Principles and Techniques*. 5<sup>th</sup> edition, Cambridge Low Price Edition.

### **Paper - 4: MIC-PG-104: Laboratory Course I**

**4 Credits**

1. Good Microbiology Laboratory Practices and Laboratory discipline.
2. Demonstration of different instruments commonly used in microbiology laboratory
3. Handling and care of microscopes
4. Calibration of microscope and measurement of microscopic objects (Bacteria, yeast and fungal filaments).
5. Staining: Preparation of stains, simple staining techniques, Differential staining techniques, Special staining techniques (smear preparation, Gram's staining, Acid fast staining (Demonstration), staining for metachromatic granules, Negative staining and spore staining).
6. Motility test by wet mount (hanging drop) and in solid media.
7. Sterilization and disinfection methods with special reference to hot air oven, autoclave, ultrafiltration
8. Preparation of culture media and biochemical reagents
9. Isolation of pure culture of bacteria by streak plate method.
10. Serial dilution and enumeration of bacteria by pour plate and spread plate methods.
11. Isolation of pure culture of fungi from the given sample by pour plate.

12. Identification of bacteria using standard biochemical tests– Carbohydrate fermentation tests (Glucose, lactose, Fructose, Sucrose, Mannitol, Arabinose) for detection of acid and gas production,
13. Identification of bacteria using standard biochemical tests– SIM, IMViC, TSI
14. Estimation of Carbohydrate
15. Isolation and estimation of Protein
16. Assay of enzymes: Amylase
17. Enzyme kinetics
18. Factor influencing enzyme activity: pH, Temperature.
19. Separation of lipids and amino acids by Paper chromatography and Thin layer Chromatography
20. Electrophoresis (Agarose and SDS-PAGE)
21. Demonstration of gas chromatography
22. Demonstration HPTLC, Biolog, PCR
23. Microbial growth curve
24. Enumeration of microbial population

#### **Reading List**

1. Baxevanis, A. D. and Ouellette, B. F. F. 2004. *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* 3<sup>rd</sup> edition, Wiley-Inter Science. USA
2. Goldman, E. and Green, L. H. 2008. *Practical Handbook of Microbiology*. 2<sup>nd</sup> edition, Francis and Taylor Group. USA
3. Krane, D. E. and Raymer, M. L. 2002. *Fundamental Concepts of Bioinformatics*. Benjamin Cummings, USA.
4. Krawetz, Stephen A. 2009. *Introduction To Bioinformatics*. New Delhi: Springer (India).
5. Plummer, D. T. 2004. *Introduction to Practical Biochemistry*. 3<sup>rd</sup> edition, Tata McGraw Hill Publishing Company Limited. India
6. White, D. and G. D. Hegeman. 1998. *Microbial Physiology and Biochemistry Laboratory: A Quantitative Approach*. Oxford University Press: New York, NY.
7. Wilson, K. and Walker, J. 2008. *Practical Biochemistry - Principles and Techniques*. 5<sup>th</sup> edition, Cambridge Low Price Edition. UK

#### **Compulsory Non-Credit Paper: National Service**

The students shall complete the requirements of “National Service” by doing some service in their own villages, towns, etc. for a period of 30 days during the winter vacation between I and II semesters. The reports of such service shall be evaluated by the departments concerned and adjudged “Satisfactory” or “Not Satisfactory”. If the report is “Not Satisfactory” they will not be eligible for the degree.

### **SECOND SEMESTER**

**Paper - 5: MIC-PG-O201: Instrumentation and Bioinformatics**

**4 Credits**

**Unit I: Microscopy, Spectroscopy and Centrifugation**

Principle and application: Light microscopy (Brightfield, Darkfield, Phase contrast, fluorescence microscopy and confocal microscopy), electron microscopy (Scanning and transmission microscopy), Atomic force Microscopy.

Spectrometric techniques: Principles of spectrophotometry (Lambert-Beer's law, scatterings), Ultraviolet and visible light spectroscopy, Fluorescence spectroscopy, Atomic spectroscopy, Infrared and Raman spectroscopy. Mass spectroscopy and MALDI – TOF, ICP-MS, NMR, XRD.

Centrifugation techniques: Preparative centrifugation and Analytical centrifugation, Care and safety aspects of centrifuges.

### **Unit II: Chromatography and Electrophoresis**

Principles and application of Chromatography. Types: Paper and thin layer chromatography, Column chromatography, gel filtration, ion exchange, affinity, high-pressure liquid, Gas-liquid, HPTLC. Electrophoresis of proteins and nucleic acids.

### **Unit III: Molecular Techniques**

Radio-isotopic and Fluorescence techniques. PCR, Real Time PCR, Blotting techniques. Molecular Markers (RAPD, RFLP, AFLP & Microsatellite); DNA Barcoding. Sequencing techniques: Sanger sequencing, Pyrosequencing, Illumina sequencing.

### **Unit IV Bioinformatics**

Types, properties and application of biological databases with suitable examples (Gene Bank at NCBI, PDB, Swiss-Prot at EBI). Working with protein (predicting secondary structure, 3-D structures, RNA), building phylogenetic trees using DNA and protein sequences. General principles involved, global /local, tools available alike BLAST, CLUSTAL-W, Similarity Searches on sequence databases, comparing two sequences, building a multiple sequence alignment, editing and publishing alignments.

### **Reading lists**

1. Davis, L. G., Dibner, M. D. and Battey, J. F. 1986. *Basic Methods in Molecular Biology*. Appleton and Lange. USA
2. Field, K. G. and Ream, W. 1999. *Molecular Biology Techniques: An Intensive Laboratory Course*. Academic Press. Sambrook, J. and Russell David, W. R. 2001. *Molecular cloning A Laboratory Manual*, Three volumes, CSHL N.Y, Ed. USA
3. Plummer, D. T. 2004. *Introduction to Practical Biochemistry*. 3<sup>rd</sup> edition, Tata Mcgraw Hill Publishing Company Limited. India
4. Sambrook, J. M., Fritsch, E. F. and Maniatis, T.1989. *Molecular Cloning: A Laboratory Manual*. 3<sup>rd</sup> edition, Cold Spring Harbor Laboratory Press. USA
5. Sharma, Kal Renganathan. 2009. *Bioinformatics*. New York: McGraw-Hill. USA
6. Suri, Shalini. 2006. *Bioinformatics*. New Delhi: A P H Pub. Corp. India
7. Wilson, K. and Walker, J. 2010. *Principles and Techniques of Biochemistry and Molecular Biology*. 7<sup>th</sup> edition, Cambridge University Press. UK

### **Unit I: Microbial Genetics**

Introduction to the Gene transfer mechanisms: transformation, transduction, conjugation. Genetic mapping with the help of conjugation and transduction; Phage genetics: Fine structure analysis of T4 rII locus; Plasmid: Introduction, classification, incompatibility, copy number control.

### **Unit II: Transcription, translation and gene regulation**

RNA polymerase structure and function, prokaryotic promoter sequence; transcription initiation, elongation and termination; anti-termination. Major differences between prokaryotic and eukaryotic transcription. Concept of genetic code, translation process in prokaryotes, translational proof-reading, translational inhibitors. Major differences between prokaryotic and eukaryotic translation. Operon – Positive and Negative regulation of *lac* operon; attenuation of *trp* operon.

### **Unit III: Transposons, RNA Molecules, Mutation**

Transposable elements (DNA transposons, viral like retrotransposons, polyA retrotransposons), mechanism of transposition; RNA interference; Mutation – mutagens, types, causes and detection of mutation. In vitro mutagenesis and deletion techniques.

### **Unit IV: Recombinant DNA technology, Genomics and Proteomics**

Phenomenon of Restriction Modification systems; molecular cloning, expression of recombinant proteins in prokaryotic and eukaryotic vectors; Preparation of cDNA libraries in plasmid, phagemid, cosmid, BAC and YAC vectors. Gene knockout in bacteria, Fluorescence *in situ* hybridization, sequence tagged site mapping; genome – structure and function, annotation, transcriptome – microarray or chip analysis; Introductory Proteomics. Introduction to unculturable microorganisms – metagenomics and microbiome.

### **Reading List**

1. **Karp, G., Iwasa, J., Marshall, W.**, 2015. *Karp's Cell and Molecular Biology*, 8<sup>th</sup> Edition, John Wiley and Sons.
2. Krebs, J.E., (Author), Goldstein, E.S. Kilpatrick, S.T. 2017. Lewin's *Genes* XII. Jones and Bartlett Publishers, Inc; 12<sup>th</sup> revised edition.
3. **Watson, J.D., Baker, T.A., Bell, S. P., Gann, A., Levine, M., Losick, R.** 2013. *Molecular Biology of the Gene*, 7<sup>th</sup> edition, Pearson.
4. Brown, T.A. 2006. *Genomes 3*, third edition, Garland Science.
5. [Primrose, S.B and Twyman, R.M.](#), 2014, *Principles of Gene Manipulation and Genomics* Paperback, seventh edition, Wiley India.
6. Maloy, S., Cronan, J.E., Freifelder, D. 2004. *Microbial Genetics (Jones and Bartlett Series in Bioogy)*. 2<sup>nd</sup> edition, Jones and Bartlett Publishers, Inc.
7. Streips, U. N. and Yasbin, R. E. 2002. *Modern Microbial Genetics*. 2<sup>nd</sup> edition, Wiley-Liss, USA.

### **Unit I: Principles of Clinical Microbiology**

Koch's Postulates. Classification of medically important microorganisms. Normal microbial flora of human body and their role. Host pathogen Interaction. Infection: Sources and vehicles of infection: waterborne, airborne, STDs, insect-borne, nosocomial. Establishment of infection: Mechanism of infection. Antimicrobials and their mode of actions.

### **Unit II: Bacterial pathogens**

Brief account of morphology, cultural characteristics, pathogenesis, clinical features, laboratory diagnosis, prevention and control of following: *Staphylococcus*, *Streptococcus*, *Pneumococcus*, *Neisseria*, *Corynebacterium*, *Clostridium*, organisms belonging to Enterobacteriaceae, *Vibrios*, *Haemophilus*, *Brucella*, *Mycobacteria*, *Spirochaetes*, *Actinomycetes*, *Acinetobacter*.

### **Unit III: Viral Pathogens**

Brief account of morphology, cultural characteristics, pathogenesis, clinical features, laboratory diagnosis, prevention and control of important viral diseases like Influenza, Polio, Hepatitis, Herpes, AIDS.

### **Unit IV: Fungal and parasitic pathogens**

Brief account of morphology, cultural characteristics, pathogenesis, clinical features, laboratory diagnosis, prevention and control of human fungal diseases. Dermatophytes, Dimorphic fungi, opportunistic fungal pathogens. Brief account of morphology, life cycle, pathogenesis, clinical features, laboratory diagnosis, prevention and control of important human parasitic diseases.

### **Reading List**

1. Ananthanarayan And Paniker., 2013. *Ananthanarayan and Paniker's Textbook of Microbiology*. C. K. Jayaram Paniker, 9<sup>th</sup> edition, Orient Blackswan. India
2. Brooks, G., Carroll, K. C., Butel, J. and Morse, S. 2007. *Medical Microbiology (Jawetz, Melnick, and Adelberg's Medical Microbiology)*. 24<sup>th</sup> edition McGraw-Hill Medical. USA
3. Collee, J.G., Fraser, A. G., Marmion, B. P. Simmons. 2011. *Mackie & McCartney Practical Medical Microbiology*. 14<sup>th</sup> edition, Churchill Livingstone. USA
4. Forbes, B. A., Sahm, D. F. and Weissfeld, A. S.2007. *Bailey and Scott's Diagnostic Microbiology*. 12<sup>th</sup> edition, Mosby. USA
5. Mims, C. A. 2004. *Medical Microbiology*. 3<sup>rd</sup> edition C.V. Mosby. USA
6. Murray, P. R., Baron, E. J., Jorgensen, J. H. and Landry, M. J.: 2007, *Manual of Clinical Microbiology* (2 Volume Set),. 9<sup>th</sup> edition, ASM Press. USA
7. P. Chakraborty. 2013. *A Textbook of Microbiology*. 3<sup>rd</sup>edition. New Central Book Agency (P) Limited, India

### **Paper - 8: MIC-PG-C204: Laboratory Course II**

**4 Credits**

1. Biosafety and Good Microbiology Laboratory Practices
2. Isolation of Genomic DNA from bacteria
3. Isolation of plasmid DNA from bacteria



4. Agarose gel Electrophoresis of the isolated genomic and plasmid DNA
5. PCR Amplification of target DNA
6. Purification of PCR amplified DNA from agarose gel
7. Quantification of DNA by UV-Visual spectroscopy
8. Bacterial transformation
9. Bacterial conjugation
10. Electrophoresis SDS-PAGE and native page
11. Demonstration of Real-Time PCR
12. Demonstration of DNA Sequencing techniques
13. Isolation and Identification of medically important bacteria from human skin, and some clinical samples like pus, urine & stool.
14. Antibiotic susceptibility testing by disc diffusion method and MIC
15. Demonstration of Acid Fast Bacilli (AFB) by ZN staining
16. Demonstration of BIOLOG for phenotypic identification of bacteria
17. Hands on Bioinformatics I: Introduction to Bioinformatics databases
18. Hands on Bioinformatics II: Nucleotide sequence searches and alignments
19. Hands on Bioinformatics III: Building Phylogenetic trees
20. Hands on Bioinformatics IV. Working with proteins
21. Hands on Bioinformatics IV. Primer designing

### Reading List

1. Arora, D.K., Surajit D., Mesapogu S., (Eds.) 2013. *Analyzing Microbes: Manual of Molecular Biology Techniques*, Springer-Verlag Berlin Heidelberg, USA
2. Carson, Sue, Heather B Miller, and D. Scott Witherow. 2012. *Molecular Biology Techniques*. Amsterdam: Elsevier /Academic Press. USA
3. Collee, J.G., Fraser, A. G., Marmion, B. P. Simmons. 2011. *Mackie & McCartney Practical Medical Microbiology*. 14<sup>th</sup> edition, Churchill Livingstone. USA
4. Cappucino, J. and Shuman, P. 2008. *Microbiology: A Laboratory Manual*. Benjamin Cummings. USA
5. Michael J. McPherson and Simon Geir Møller. 2006. *PCR*. Taylor and Francis, Madison Avenue, NY
6. Sambrook, J. and Russell David, W. R. 2001. *Molecular cloning A Laboratory Manual*, Three volumes, CSHL N.Y, Ed., USA
7. Wilson, Keith. 2911. *Principles and Techniques of Biochemistry And Molecular Biology*. Cambridge: Cambridge Univ. Press. UK

### THIRD SEMESTER

**Paper - 9: MIC-PG-C301: Agricultural and Industrial Microbiology**

**4 Credits**

**Unit I: Rhizosphere, Nitrogen Fixation, Biofertilizers**

Microorganisms of soil, rhizospheres and Phylloplane, Microbial ecology of soil with respect to biotic and abiotic factors. Endophytic microorganisms and Mycorrhiza: PGPR. Nitrogen cycle and Biological Nitrogen Fixation in Symbiotic and Free living microorganisms. Phosphorus cycle and Phosphate solubilizing bacteria. Biofertilizers – Types and Application. Antibiosis and Biological control. Biopesticides. Humus Formation.

### **Unit II: Genetic Engineering in Agriculture**

Significance of *Agrobacterium tumefaciens* and viral vectors in development of transgenic plants. Antisense RNA technology. Brief discussion of Bt cotton, Beta-Carotene Maize, Golden Rice, Rainbow Papaya, Flavr-Savr. Concept of edible vaccine as biopharmaceuticals (ZMAPP). Genetically Modified Microorganisms: *Pseudomonas syringe* (Ice-minus), *P. putida*. Regulatory issues in using genetically modified organisms.

### **Unit III: Introduction to Industrial Microbiology and Fermentation Principles**

Bioprocess Technology. Types of Fermenters. Fermentation in batch culture: Media formulation, Microbial growth kinetics (Batch and Continuous kinetics), Effect of growth and nutrient, Condition on product formation. Industrial application of enzymes. Solid-State and submerged fermentation; mechanically & non-mechanically agitated fermenters.

### **Unit IV: Typical fermentations, Industrial strains and Immobilization technique**

Fermentation processes: optimization, screening, strain improvement and factors affecting downstream processing and recovery. Fermentative production of antibiotics (Penicillin), Solvents (Ethanol), Biopolymer (PHAs) and Recombinant DNA products e.g. Insulin and amylase. Immobilized Enzyme and Cell based biotransformation. Biosensors. Biofuels.

### **Reading List**

1. Biswas, P. K. 2008. *Agricultural Microbiology*: Dominant Publishers and Distributors. New Delhi, India
2. Boland, G. J. and Kuykendall, L. D. 1998. *Plant-Microbe Interactions and Biological Control*. Marcel Dekker Inc., New York.
3. Casida, L.E. 2005. *Industrial Microbiology*. 2<sup>nd</sup> edition. New Age International Limited.
4. Crueger, W. and Crueger, A. 2003. *Biotechnology: A textbook of Industrial Microbiology*. Panima Publishing Corporation.
5. Stanbury, P. F., Hall, S. J. and Whitaker, A. 1999. *Principles of Fermentation Technology*. 2<sup>nd</sup> edition, Butterworth-Heinemann.
6. Subba Rao, N. S. 2016. *Advances in Agricultural Microbiology*. Elsevier Science.

### **Paper - 10: MIC-PG-302: Environmental Microbiology**

**4 Credits**

### **Unit I: Aquatic, Atmospheric and Extreme Environments**

Microbial habitats in the aquatic environment- Planktonic, Benthic, Microbial Mats, Biofilms. Freshwater environments, brackish water, marine water, subterranean water. Aeromicrobiological Pathway (Launching, Transport and Deposition); Extramural and Intramural aeromicrobiology. Bioaerosol control. General characteristics and mechanisms of adaptation of extremophiles. General stress signaling pathways in microorganisms.

## **Unit II: Microbial Communication**

Quorum sensing in Gram-negative bacteria –Role of N acyl homoserine lactones. The *Agrobacterium tumefaciens* Tra I/Tra R virulence system and the *Vibrio fischeri* Lux I/Lux R bioluminescence system. Peptide mediated quorum sensing in Gram-positive bacteria. The *Staphylococcus aureus* Agr C/ Agr A virulence system.

## **Unit III: Microbial Biodegradation and Bioremediation**

Concept of biotransformation and biodegradation of organic pollutants (Aliphatic, alicyclic, aromatic) and factors affecting biodegradation. Biodegradation of xenobiotics - pesticide catabolism, reductive and aerobic dechlorination. Microbial leaching of ores and metal recovery.

## **Unit IV: Solid and Liquid Waste Management**

Types and sources of solid waste; methods of treatment of solid wastes. Wastewater treatment (Primary, secondary and tertiary) processes. Indicator microorganisms for fecal contamination. Drinking water purification (Physical and Chemical purification, Disinfection).

## **Reading List**

1. Anitori, R. P. 2012. Extremophiles: Microbiology and Biotechnology, Caister Academic Press.
2. Bitton, G. 2010. Wastewater Microbiology. Fourth Edition, Wiley –Blackwell.
3. Madigan, M.T. Martinko, J.M., Stahl, D.A. and Clark, D.P. 2010. Brock Biology of Microorganisms, 13th edition, Pearson Benjamin-Cummings, San Francisco.
4. Nag, A. and Vizayakumar, K. 2005. Environmental Education and Solid Waste Management. New Age International (P) Ltd. Publishers, New Delhi.
5. Pepper, I.L, Gerba, C.P. and Gentry, T J. (Eds) 2014. Environmental Microbiology, third edition, Academic Press.

## **Paper - 11: MIC-PG-O303: Immunology**

**4 Credits**

### **Unit I: Introduction to Immune system**

Innate immune response and its components; adaptive immune response, Organs, cells and molecules involved in immune system, antigen and structure of antibody.

### **Unit II: Structure and Development of Immune system**

B and T cell receptor, Development of B and T cells, Antigen presentation, Hypersensitivity, Cytokines and Complement system.

### **Unit III: Diseases due to innate and adaptive immunity and Immune evasion**

Polymorphs, mast cells, phagocytosis, NK cells, dendritic cells and cytokine network. Hypersensitivity, autoimmune disease.

Bacterial and Viral immune evasion.

#### **Unit IV: Vaccine and Immunological techniques**

Different types of vaccines, Monoclonal and polyclonal antibodies, Immuno-techniques including ELISA, Immunofluorescence, Immunoprecipitation.

#### **Reading List**

1. Banerjee, A. K. and Banerjee, N. 2006. *Fundamentals of Microbiology and Immunology*, New Central Book Agency (Pvt.) Ltd., Kolkata.
2. Hall, Angela, and Christine Yates. 2010. *Immunology*. Oxford: Oxford University Press.
3. Kindt, Osborne, B. A. and Richard, A. and Goldsby, R. A. 2006. *Kuby Immunology (Kindt, Kuby Immunology)*. 6<sup>th</sup> edition, W. H. Freeman.
4. Owen, Judith A, Janis Kuby, Jenni Punt, and Sharon A Stanford. 2013. *Immunology*. Basingstoke: Macmillan Higher Education.
5. Paul, W. E. 2003. *Fundamental Immunology*. 5<sup>th</sup> edition, Lippincott Williams and Wilkins Publishers, USA.
6. Pier, G. B., Lyczak, J. B. and Wetzler, L. M. 2004. *Immunology, Infection, and Immunity*. 1<sup>st</sup> edition, ASM Press.
7. Playfair, J. Bancroft, G. 2008. *Infection and Immunity*. 3<sup>rd</sup> edition, Oxford University Press. New York.

#### **Paper - 12: MIC-PG-C304: Laboratory Course III**

**4 Credits**

1. Isolation and identification of microbes from environmental samples.
2. Microbial testing of water
3. Assessment of air microbial quality
4. Estimation of BOD from sewage samples
5. Isolation, characterization and identification of thermophilic and psychrophilic bacteria
6. Preparation of plant extracts by solvent extraction (methanol/ethanol)
7. Antibacterial activity of plant extracts by well diffusion method
8. Demonstration of Immuno-techniques like Agglutination, Precipitation Immuno-precipitation
9. Demonstration of western blot and ELISA
10. Separation of different blood cells by ficoll method
11. Demonstration of BIOLOG for phenotypic identification.
12. Ethanol production from any starchy materials
13. Estimation of Ethanol
14. Fermentation for the production of amylase and penicillin
15. Enumeration of total bacterial, fungal and Actinomycetes counts from rhizospheric soils by pour & spread plate method
16. Isolation of endophytic bacteria
17. Isolation of symbiotic nitrogen fixers from leguminous/non-leguminous root nodules
18. Determination of Biocontrol activity of endophytic bacteria

19. Qualitative and quantitative evaluation of phosphate solubilization activity by soil isolates
20. Qualitative evaluation of siderophore production by soil isolates.
21. Demonstration of bio-fertilizer preparation.

### Reading List

1. Aga, Diana S. 1997. *Immunochemical Technology For Environmental Applications*. Washington, DC: American Chemical Society.
2. Cappuccino, J. G. and Sherman, N. 2007. *Microbiology- A Laboratory Manual*, Seventh Edition, Pearson Education, Inc. and Dorling Kindersley(Indi) Pvt Ltd, Delhi, India.
3. Hay, F.C. and Westwood, O.M.R. 2002. *Practical Immunology*. Fourth Edition, Blackwell Science.
4. Hurst, C. J., Crawford, R. L., Knudsen, G. R., McInerey, M. J. and Stetzenbach, L. D. 2002) *Manual of Environmental Microbiology*, Second edition. ASM Press, Washington DC.
5. Malik, Vedpal S, and Erik P Lillehoj. 2013. *Antibody Techniques*. Burlington: Elsevier Science.
6. Harborne, J. B. *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. 2012. Springer Science & Business Media.
7. Alexander, M. 1977. *Soil Microbiology*. John Wiley.
8. Ila, Rodolfo O, Patricio S Faylon, William D Dar, William D Batchelor, Riyaz Sayyed, Hari K Sudini, K. Vijay Krishna Kumar, Adoracian B Armada, S Gopalakrishnan, and M. S Reddy. 2014. *Recent Advances In Biofertilizers And Biofungicides (PGPR) For Sustainable Agriculture*. Newcastle upon Tyne: Cambridge Scholars Publishing.

## FOURTH SEMESTER

### Paper – 13: MIC-PG-C401: Food Microbiology

4 Credits

#### Unit I: Taxonomy and Microorganisms associated with the food

Taxonomic Tools and Approaches to study microorganisms associated with the foods. Food preservation: Principle of food preservation, asepsis, preservation by temperature, radiations, chemicals; bio-preservation, Hurdle concept in food preservation.

#### Unit II: Microbiology of food, Foodborne illness

Characteristics and clinical features of foodborne diseases caused by *Salmonella* and *Shigella*, *Escherichia coli*, *Staphylococcus aureus*, *Clostridium botulinum*, *Bacillus cereus* *Listeria monocytogenes*, viruses, prions. Food poisoning due to algal toxins, bacterial toxins and mycotoxins, viruses; predictive microbiology.

#### Unit III Fermented foods and beverages

Methods of production, mode of consumption, microbiology and nutrition: Himalayan fermented foods (*any two*): *gundruk*, *kinema*, *chhurpi*, *soibum*, *ngari*. Indian fermented foods (*any one*): *dahi*, *idli*, *dosa*, *rabdi*, *wari*. Oriental fermented foods (*any one*): *natto*, *kimchi*, *tempeh*, *soysauce*, *miso*. European fermented foods (*any one*): *cheese*, *sausage*, *sauerkraut*, *yogurt*, *sourdough*. African fermented foods (*any one*): *dawadawa*, *gari*, *kenkey*, *mageu*, *ogi*. Alcoholic beverages (*any two*): *kodo ko jaanr*, *sake*, *wine*, *beer*.

#### **Unit IV: Food Safety, Probiotics**

Food Safety Management: Codex Alimentarius, Hazard Analysis and Critical Control Point (HACCP) System- definition, application; Indicators of food quality- microbial indicator and microbial metabolites. Probiotics: Definition, characteristic and criteria of probiotic microorganisms, beneficial effects of probiotic bacteria; prebiotics and synbiotics.

#### **Reading List**

1. Adams, M. R. and Nout, M. J. R. 2001. *Fermentation and Food Safety*. Aspen Publishers Inc., Maryland.
2. Hutkins, R.W. 2006. *Microbiology and Technology of Fermented Foods*. Blackwell Publishing.
3. Jay, J. M., Loessner, M. J. and Golden, D. A. 2005. *Modern Food Microbiology*. 7<sup>th</sup> Edition, Springer, NY.
4. Omaye, S.T. 2004. *Food and Nutritional Toxicology*. CRC Press, London
5. Steinkraus, K. H. 1996. *Handbook of Indigenous Fermented Food*. 2<sup>nd</sup> edition, Marcel Dekker, Inc., New York.
6. Tamang, J.P. 2009. *Himalayan Fermented Foods: Microbiology, Nutrition and Ethnic Values*. Taylor and Francis Group, USA.
7. Tamang, J.P. and Kailasapathy, K. 2009. *Fermented Foods and Beverages of the World*. Taylor and Francis Group, USA.
8. Wood, B.J.B. 1998. *Microbiology of Fermented Foods*. 2 volumes, 2<sup>nd</sup> edition, Elsevier Applied Science Publications.

#### **Paper - 14: MIC-PG-C402: Molecular Virology**

**4 Credits**

##### **Unit I: Nature of viruses**

Modern classification of viruses. Concept of viroid's, satellite viruses, virusoids and prions. Structure of viruses and their cultivation. Capsid symmetry and virus architecture. Protein nucleic acid interaction.

##### **Unit II: Techniques in virology and viral vaccines**

Virus cultivation, Detection of viruses: (Complement fixation tests (CFT), Single Radial Haemolysis, Recombinant immunoblot assay (RIBA)). Quantification of viruses: Physical methods (TEM, PCR, qPCR, ELISA), Biological methods (Plaque assay, hemagglutination assay, Endpoint assay). Viral vaccines: Interferons and antiviral drugs.

##### **Unit III: Bacterial and Plant Viruses**

Bacterial Viruses: Viral multiplication and replication strategies of T4, T7,  $\Phi$ X174. Plant Viruses: Viral multiplication and replication strategies of Tobacco Mosaic Virus, Cauliflower Mosaic Virus.

##### **Unit IV: Animal Viruses**

Epidemiology, molecular pathogenesis, diagnosis, prevention and treatment of RNA viruses, Picorna, Corona, Orthomyxo, Paramyxo, Toga, Flavi and other arthropod viruses, Rhabdo, Rota, HIV and other Oncogenic viruses; DNA viruses: Pox, herpes, Adeno, Papilloma; Hepatitis viruses.

#### **Reading List:**

1. Cann, Alan J. 2016. *Principles Of Molecular Virology*. London: Elsevier.

2. Carter, J. and Saunders, V. 2007. *Virology: Principles and Applications*. First edition Wiley.
3. Dimmock, N.J., Primrose, S.B. 1994. *Introduction to Modern Virology*, 4<sup>th</sup> edition, Blackwell Scientific Publications, Oxford.
4. Fields, B.N. et al. 2001. *Fields-Virology, Vol I and II*, 4<sup>th</sup> edition. Lippincott Williams & Wilkins Publishers.
5. Harper, D.R. 1993. *Virology Labfax*. Oxford: BIOS Scientific Publishers.
6. Modrow, Susanne. 2013. *Molecular Virology*. Heidelberg [u.a.]: Springer.
7. Tiwari, V. N. 2012. *Virology*. Jodhpur: Agrobios (India).

**Paper - 15: MIC-PG-403: Laboratory Course IV**

**4 Credits**

1. Isolation of bacteriophages
2. Aseptic handling and cultivation of animal cell culture
3. Cell counting by Hemocytometer
4. Isolation of animal viruses
5. Quantification of viruses by plaque assay/Real Time PCR.
6. Microbiology and quality assessment of any fermented.
7. Microbiology and quality assessment of non-fermented food samples.
8. Isolation of dominant microorganisms from fermented food – cereal and vegetable products (any local product): *Bacillus*/Lactic acid bacteria/ yeasts/coliforms.
9. Identification of dominant microorganisms from food samples by phenotypic characteristics.
10. Microbiological analysis of milk, meat, eggs.
11. Estimation of carbohydrates and proteins in fresh/fermented food samples.
12. Estimation of lipids from food samples.

**Reading List**

1. Harrigan, W.F. 1998. *Laboratory Methods in Food Microbiology*. 3<sup>rd</sup> edition. Academic Press, London.
2. Roberts, D. and Greenwood, M. 2002. *Practical Food Microbiology*. 3<sup>rd</sup> edition, Wiley-Blackwell.
3. Cappucino, J. and Shuman, P. 2008. *Microbiology: A Laboratory Manual*. Benjamin Cummings.
4. Nielsen, Suzane S. 2010. *Food Analysis Laboratory Manual*. Springer, NY
5. Fields, B.N. et al. 2001. *Fields-Virology, Vol I and II*, 4<sup>th</sup> edition. Lippincott Williams & Wilkins Publishers.
6. Desselberger, U. 1998. *Medical Virology: A Practical Approach*. Oxford University Press, UK.

**Paper -16: MIC-PG-C404: Dissertation****4 Credits**

The students shall submit dissertations and defend their methodologies and findings before the entire faculty plus one external examiner at the end of the IV semester. The average of marks given by internal faculty members shall be counted out of 50% and the external examiner shall mark out of the remaining 50%.

<b>Sl. No</b>	<b>Details</b>	<b>Internal Examiner</b>	<b>External Examiner</b>	<b>(Total Marks=100)</b>
1.	# Dissertation findings  #Further advancement (Future scope) of Assigned dissertation topic followed by a brief review of literature on the same.	25	25	50
2.	Thesis Evaluation and Viva-voce.	25	25	50
Total Marks				100

Evaluation shall be done by all the Faculty members of the Department and one external examiner.

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