University of Lucknow
Master of Science Programme
Regulations 2020

1. **Applicability**

   These regulations shall apply to the **Master in Microbiology** programme from the session 2020-21.

2. **Minimum Eligibility for admission**

   A three/four-year Bachelor's degree or equivalent in Science (Biology group) awarded by a University or Institute established as per law and recognised as equivalent by this University with minimum 45% percentage marks or equivalent grade, shall constitute the minimum requirement for admission to the Master in Microbiology programme.

3. **Programme Objectives**

   The M.Sc. Microbiology programme covers all aspects of Microbiology and involves classical, modern and inter-disciplinary approaches. The proposed syllabus endeavours to provide training in microbiological skills through lectures, projects, practical exercises and seminars/presentations.

4. **Programme Outcomes**

   After completion of the two year Course in Microbiology, the students would have:

   - Gathered substantive knowledge that prepares post graduates for careers in areas of Biochemistry, Medical Microbiology, Environmental and Food Sciences, Molecular Biology and Biotechnology.
   - Developed an exploratory mind-set along with problem-solving and analytical skills, to enable a smooth progress into the area of research and teaching.
   - Accumulated skills such as critical scientific thinking needed for data analysis.
   - Received training in the preparation of a Dissertation from the Internship in the last Semester, designed as a vital, gainful component of practical training for the students.

5. **Specific Programme Outcomes (PSOs)**

   PSO1: Students pursuing the course will be able to explore the diversity of the microbial world, the structure and function of microbes/microbial cells.

   PSO2: Students will be familiarized with the multitude of techniques involved in microbial study ranging from culture and microscopy to molecular.

   PSO3: Students will be able to understand the role of microbes in evolution and life on earth, natural environments and microbial ecosystems.

   PSO4: Students will be able to appreciate the impact of microbes in biotechnology, industry, agriculture, health and medicine.

6. Course Structure

The course structure of the **Master in Microbiology** programme shall be as under:

Course No.	Name of the Couse	Credit	Course Type
	Semester I		
MIC-CC-101	**Techniques and Tools in Microbiology**	**04**	**Core Course**
MIC-CC-102	**Microbial Diversity**	**04**	**Core Course**
MIC-CC-103	**Cell Structure**	**04**	**Core Course**
MIC-CC-104	**Microbial Genetics**	**04**	**Core Course**
MIC-CC-105	**Practical based on MIC-CC-101 to MIC-CC-104**	**04**	**Core Course**
BOT-VC-101	**Conservation of Plant Diversity**	**04**	**Value added course (Credited)**
	Semester Total	**24**	
	Semester II		
MIC-CC-201	**Microbial Physiology and Biochemistry**	**04**	**Core Course**
MIC-CC-202	**Molecular Biology and Genetic Engineering**	**04**	**Core Course**
MIC-CC-203	**Plant Virology**	**04**	**Core Course**
MIC-CC-204	**Environmental Microbiology**	**04**	**Core Course**
MIC-CC-205	**Medical Microbiology and Immunology**	**04**	**Core Course**
MIC-CC-206	**Practical based on MIC-CC-201 to MIC-CC-205**	**04**	**Core Course**
BOT-VNC-201	**Art of Bonsai**	**00**	**Value added course (Non-Credit)**
	Semester Total	**24**	
	Semester III		
MIC-CC-301	**Microbial Biotechnology and Bioinformatics**	**04**	**Core Course/ MOOC**
MIC-CC-302	**Industrial and Food Microbiology**	**04**	**Core Course**
BOT-EL-301A	**Applied Botany-I**	**04**	**Elective**
BOT-EL-301B	**Analytical Techniques and Computer Applications**		
BOT-EL-302A	**Mushroom Cultivation**	**04**	**Elective**
BOT-EL-302B	**Ecotourism**		
MIC-IN-301	**Summer Internship**	**04**	**Internship**
BOT-IER-301	**Plant Resource Utilization**	**04**	**Inter-departmental Course**
	Semester Total	**24**	
	Semester IV		
MIC-SI-401	**Semester Internship**	**24**	**Full Semester Internship**
	Semester Total	**24**	
	GRAND TOTAL	**96**	

MIC – Microbiology; CC – Core Course; BOT-VC – Value added course (Credited); BOT-VNC - Value added course (Non Credited); BOT-EL –Elective; IN – Summer Internship; BOT-IER – Interdepartmental Course; SI-Semester Internship

7. Course Outlines

M.Sc. MICROBIOLOGY (SEMESTER – I)
MIC-CC-101: TECHNIQUES AND TOOLS IN MICROBIOLOGY
4 Credits/40 Hours

Course Outcomes:
After completion of the Course, the student will:

- Learn the concept of sterile techniques for isolation of microbes in pure culture, and understand the principles of optical microscopy including generation of contrast.
- Gain knowledge about the instrumentation, working principle and applications of varied forms of spectroscopy needed to study bio-molecules and crystal structures.
- Understand chromatographic techniques for separation of bio-molecules.
- Understand the working principle behind electrophoresis, and study of antigen-antibody interactions, including applications for the identification of microbes.
- Learn centrifugation techniques, and forms of electron microscopy for the purification and characterization of microorganisms.

Unit – I
Pure cultures, culture media (defined/synthetic, complex, selective, differential, enriched)
Aseptic conditions, sterilization techniques, inoculation methods (spread-plate, streak-plate, pour-plate)
Culture characteristics, culturing for specific requirements e.g. antibiotic sensitivity
Principles of staining, Gram stain, staining for *Mycobacterium*, endospore, capsule, flagella
Principles of microscopy, compound microscope, phase contrast microscope, fluorescence microscope
Unit – II
Principle, instrumentation and applications of: UV and visible light Spectrophotometry
Spectrofluorimetry
Atomic absorption spectroscopy
Tracer techniques (Types of radioactive decay, detection and measurement of radioactivity by Geiger-Muller and scintillation counting, Autoradiography)
Unit – III
Paper and Thin Layer chromatography
Components of Column chromatography, HPLC
Types of Column chromatography: Ion-exchange, Affinity, Hydrophobic Interaction, Reverse-phase, Size-exclusion
Gas chromatography
Unit – IV
Purification of plant viruses, Bioassay
Test for viral purity, Quantification
Electron microscope, SEM, TEM, Stains in electron microscopy
Ultracentrifugation, Density gradient centrifugation
Unit – V
Polyacrylamide gel electrophoresis (native and SDS), 2D electrophoresis, Isoelectric focusing
Serology (Ouchterlony gel diffusion, ELISA, Immunoblotting)
Immuno-sorbent electron microscopy (ISEM), RIA
Molecular methods of virus identification (Southern blotting, Northern blotting, PCR)
Practical based on Units I – V

Suggested Readings:

1. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology, Edited by A. Hofmann, S. Clokie, 8th edition, 2018, Cambridge University Press.
2. Protein Purification Techniques: A Practical Approach, Edited by S. Roe, 2001, Oxford University Press.
3. Modern Experimental Biochemistry, R. Boyer, 3rd edition, 2002, Pearson Education.
4. Laboratory Manual of Microbiology and Biotechnology, K.R. Aneja, 2016, Scientific International Pvt. Ltd.
5. Microbiology: A Laboratory Manual, James G. Cappuccino, Chad T. Welsh, 10th edition, 2014, Pearson Education.

M.Sc. MICROBIOLOGY (SEMESTER – I)
MIC-CC-102: MICROBIAL DIVERSITY
4 Credits/40 Hours

Course Outcomes:

After completion of the Course, the student will:

- Know about bacterial and archaeal diversity in a morphological and phylogenetic context.
- Know how to classify and compare the morphological and genomic characteristics of plant viruses.
- Learn the diversity of fungi and algae along with their comparative structure and classification.
- Understand the characteristics of pathogenic nematode and protozoa.
- Learn about the pathogenic aspects of the various groups of microorganisms, their disease cycles and control measures.

Unit – I
Classification, characteristics and diversity of Bacteria and Archaea with special reference to: *Xanthomonas oryzae, Erwinia carotovora*
Ralstonia(*Pseudomonas*) *solanacearum*
Streptomyces scabies, Agrobacterium tumefaciens
Phytoplasma, Spiroplasma and *Mycoplasma*
Archaea (extreme halophiles, methanogens, hyperthermophiles)
Unit – II
Classification, characteristics and diversity of Plant Viruses with special reference to: Cucumber mosaic virus (CMV)
Tobacco mosaic virus (TMV)
Tomato yellow leaf curl virus (TYLCV)
Papaya ringspot virus (PRSV)
Bhendi yellow vein mosaic virus (BYVMV)
Unit–III
Classification, characteristics and diversity of Fungi and Algae with special reference to: *Alternaria sp., Penicillium sp., Yeast*
Uromyces sp., Peronospora sp.
Prochloron, Anabaena sp., Gloeotrichia sp.
Cosmarium sp., Trentepohlia sp., Padina sp.
Unit–IV
Classification, characteristics and diversity of Protozoa and Nematodes with special reference to: *Entamoeba sp.*
Paramecium sp.
Giardia sp.
Meloidogyne sp.
Ascaris sp.
Unit–V
Pathogenic aspects, disease cycles and control measures of: Bacteria: *Xanthomonas oryzae/*leaf blight of rice, *Erwinia carotovora/*soft rot of carrots and onions, *Streptomyces scabies/*potato scab, *Agrobacterium tumefaciens/*crown gall disease, Ca. *Phytoplasma sp.*/little leaf of brinjal
Virus: CMV/cucumber mosaic, TMV/tobacco mosaic, TYLCV/tomato yellow leaf curl, PRSV/papaya ringspot, BYVMV/bhendi yellow vein mosaic
Fungi: *Alternaria brassicae* and *A. brassicicola/*leaf spot of crucifers, *Uromyces ciceris-arietini/*gram rust, *Peronospora* sp/downy mildew
Protozoa and Nematodes: *Entamoeba histolytica/*Amoebiasis, *Giardia lamblia/*Giardiasis, *Meloidogyne incognita/*root knot, *Ascaris lumbricoides/*Ascariasis
Practical based on Units I –V

Suggested Readings:

1. Plant Pathology, G.N. Agrios, 5th ed, 2005, Elsevier.
2 Introductory Mycology, C.J. Alexopoulos, C.W. Mims and M. Blackwell, 4th edition, 1996, Wiley India.
3. Microbiology: An Introduction, G.J. Tortora, B.R. Funke, C.L. Case, 11th edition, 2016, Pearson India Education.
4. Plant Diseases, R.S. Singh, 10th edition, 2019, Scientific International Pvt. Ltd.
5. Phycology, Robert Lee, 4th edition, 2008, Cambridge University Press
6. Microbiology with Diseases by Taxonomy, RW Bauman, 4th edition, 2017, Pearson India Education.
7. Matthew's Plant Virology, R. Hull, 4th edition, 2003, Elsevier.
8. Prescott's Microbiology, J. Willey, L. Sherwood, 10th edition, 2017, McGraw-Hill Education
9. A Textbook of Microbiology, R.C. Dubey and D.K. Maheshwari, 3rd edition, 2013, S Chand and Co.

M.Sc. MICROBIOLOGY (SEMESTER – I)
MIC-CC-103: CELL STRUCTURE
4 Credits/40 Hours

Course Outcomes:
After completion of the Course, the student will:

- Be able to compare prokaryotic and eukaryotic cell structure and function.
- Know the structure and role of cell components such as cell wall, membrane, and the cytoskeletal elements.
- Understand the structure and function of cell organelles.
- Learn about microbial growth, methods for its measurement, and factors affecting it.
- Get an overview of microbial cell cycle and movement in response to external stimuli.

Unit – I
Cell structure and organization in prokaryotes and eukaryotes
General structure of a Bacterial cell and Mycoplasma
General structure of Viruses, Algae
General structure of Fungi, Protozoa
Unit – II
Structure and function of: Cell wall and Plasma membrane
Lysosomes and Golgi bodies
Microtubules, Microfilaments, Intermediate filaments
Unit – III
Structure and function of: Nucleus
Mitochondria
Chloroplast
Ribosomes
Unit – IV
Bacterial growth principles (binary fission and growth curve)
Measurement of microbial growth (Standard plate count/viable count, direct microscopic count using Petroff-Hausser counting chamber, turbidity measurement)
Factors affecting bacterial growth (temperature, oxygen, pH, hydrostatic and atmospheric pressure)
Unit – V
Cell cycle
Cell synchrony
Continuous and synchronous cultures
Taxic movements
Practical based on Units I –V

Suggested Readings:

1. Molecular Biology of the Cell, B. Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter, 6th edition, 2014, Norton and Company.
2. Molecular Biology of the Gene, J.D. Watson, 7th edition, 2017, Pearson India Education.
3. Cell Biology, G. Karp, 7th edition, 2013, Wiley India.
4. Cell and Molecular Biology, P.K. Gupta, 2005, Rastogi Publications
5. Lewin's Genes XII, J. Krebs, E. Goldstein, S.T. Kilpatrick, 12th edition, 2017, Jones and Bartlett.

M.Sc. MICROBIOLOGY (SEMESTER – I)
MIC-CC-104: MICROBIAL GENETICS
4 Credits/ 40 Hours

Course Outcomes:
After completion of the Course, the student will:

- Understand the concept of Mendelian inheritance, genetic linkage and crossing over.
- Understand the organization of the bacterial chromosome, plasmid, and the eukaryotic genome, and the mechanism of DNA replication.
- Learn about the molecular basis of mutations and mechanisms of DNA repair.
- Know about the bacteriophage diversity and replication pathways of virulent and temperate phages, and working of the genetic switch in bacteriophage Lambda
- Understand the stages in mitotic and meiotic cell division, and the mechanisms of genetic recombination in bacteria.

Unit – I
Mendelian principles
Neurospora genetics
Linkage and crossing over (Mechanism, significance)
Unit – II
Genome organization in bacteria and eukaryotes (DNA packaging, general aspects of organization of genes in bacteria and eukaryotes, C-value paradox)
Types of genomes in viruses, genome organization of tobacco mosaic virus
DNA replication (DNA polymerase holoenzyme, mechanism, clamp loading, proof-reading)
Plasmids (Organization, F-plasmid, R-plasmid, Ti plasmid, ColE1 plasmid replication control)
Unit – III
Genetic code (Discovery, significance, degeneracy)
Types of mutations (Point mutations [substitution, addition, deletion], frameshift, silent)
Molecular mechanisms of mutations (Induction, reversions)
DNA repair mechanisms (Base excision, mismatch, double strand break, SOS)
Unit – IV
Diversity of phage genomes
Life cycle of bacteriophage (lytic, lysogenic)
Genetic switch of phage Lambda (Biphasic nature, λ repressor, induction of switch)
Unit – V
Cell division: Mitosis
Cell Division: Meiosis
Genetic recombination in bacteria (General principles, transformation, transduction, conjugation)
Practical based on Units I – V

Suggested Readings:

1. Concepts of Genetics, W.S. Klug, M.R. Cumming, C.A. Spencer and M.A. Palladino, 10th edition, 2016, Pearson India Education.
2. Cytogenetics, P.K. Gupta, 2007, Rastogi Publications.
3. Molecular Biology of the Cell, B. Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter, 6th edition, 2014, Norton and Company.
4. Molecular Biology of the Gene, J.D. Watson, 7th edition, 2017, Pearson India Education.
5. Molecular Genetics of Bacteria, L. Snyder, 3rd edition, 2007, American Society for Microbiology.
6. Molecular Cell Biology, H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretcher, H. Ploegh, P. Matsudaira, 6th edition, 2007, W.H. Freeman.

M.Sc. MICROBIOLOGY (SEMESTER - II)
MIC-CC-201: MICROBIAL PHYSIOLOGY AND BIOCHEMISTRY
4 Credits/40 Hours

Course Outcomes:
After completion of the Course, the student will:

- Understand the structure of macromolecules and their basic building blocks
- Know the mechanisms of ATP generation by microbes, and importance of heterotrophic metabolism, fermentation and chemolithotrophy.
- Learn the generation of ATP in a light driven process and pathways of CO_2 fixation by phototrophic microorganisms.
- Understand how enzymes, the biological catalysts, work and factors affecting their catalytic function.
- Know about nucleic acids and their building blocks, enzyme specificity, energy-rich compounds and biological nitrogen fixation.

Unit – I
Carbohydrates
Lipids
Amino acids
Proteins
Unit – II
Oxidative phosphorylation, Substrate-level phosphorylation, ATP synthase and ATP generation
Chemolithotrophy (oxidation of hydrogen, iron, and reduced sulphur and inorganic nitrogen compounds by bacteria)
Glycolysis and TCA cycle, anaerobic respiration (Denitrification, sulphate and sulphur reduction)
Fermentative diversity, Lactic acid fermentation (Homofermentative and Heterofermentative pathways), Alcoholic fermentation
Unit – III
Types of bacterial photosynthetic pigments (chlorophyll, bacteriochlorophyll, chlorosomes, carotenoids, phycobilins), reaction centres and antenna pigments, photosynthetic membranes
Anoxygenic and oxygenic photosynthesis, Electron flow in purple, green and cyanobacteria, generation of reducing power and ATP
Carboxysomes, pathways for CO_2 fixation (Calvin cycle, reverse citric acid cycle, hydroxypropionate pathway, Acetyl-CoA pathway)
Unit – IV
Nomenclature and classification of enzymes
Modes of action
Kinetics and regulation
Enzyme inhibition and allosteric control
Unit –V
Nucleic acids
Nature and specificity of enzymes
Redox tower, Electron carriers, Electron Transport System and generation of the PMF, Energy-rich compounds (Coenzyme A)
Asymbiotic and symbiotic nitrogen fixation and Nitrogenase complex
Practical based on Unit I –V

Suggested Readings:

1. Lehninger Principles of Biochemistry, Nelson and Cox, 7th edition, 2017, W.H. Freeman.
2. Prescott's Microbiology, J. Willey, L. Sherwood, 10th edition, 2017, McGraw-Hill Education.

3. Molecular Cell Biology, H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretcher, H. Ploegh, P. Matsudaira, 6th edition, 2007, W.H. Freeman.
4. Biochemistry, D. Voet and J.G. Voet, 4th edition, 2010, Wiley.
5. Biochemistry, U. Satyanarayana and U. Chakrapani, 2017, Elsevier.
6. Brock Biology of Microorganisms, M.T. Madigan, J.M. Martinko, P.V. Dunlap, D.P. Clark, 12th edition, 2008, Pearson.

M.Sc. MICROBIOLOGY (SEMESTER - II)
MIC-CC-202: MOLECULAR BIOLOGY AND GENETIC ENGINEERING
4 Credits/40 Hours

Course Outcomes:
After completion of the Course, the student will:

- Understand the regulation of transcription through the various operons, and the mechanics of translation in bacteria.
- Know about enzymes, vectors and cloning strategies in genetic manipulation.
- Learn about recombinant DNA technology and methods of DNA sequencing.
- Understand the protocol for cloning of a DNA fragment in a plasmid vector, transformation of bacterial cells and screening of cDNA libraries to identify a clone of interest.
- Learn techniques in molecular biology such as PCR, RFLP and DNA microarray that are useful in diagnosis.

Unit – I
Structure of a bacterial gene (Operon model)
Transcription and post-transcriptional processing of mRNA
Regulation of gene expression (Operon model)
lac Operon, *trp* Operon (Organization, regulation, repression)
Unit – II
Translation and post-translational processing of proteins
Introduction to recDNA technology (General concepts, isolation, purification and visualization of genomic and plasmid DNA)
DNA sequencing
Unit – III
Enzymes used in recDNA technology (Restriction endonuclease, Ligase, DNA polymerase, Reverse transcriptase)
General properties of vectors, pBR322, ColE1 origin of replication, α-complementation, pUC vectors, phage lambda DNA as vector, cosmids
Expression vectors
Cloning strategies (Restriction digestion, ligation, linkers, adapters, homopolymer tails, directional cloning, TA-cloning)
Unit – IV
cDNA and genomic libraries (Generation of cDNA, CAPture method for full length cDNA, generation of genomic library)
Screening methods and characterization of cloned inserts (Insertional inactivation, α-complementation, hybridization, immunological screening, bait-prey two hybrid system)
Bacterial transformation methods (Preparation of competent cells, transformation by heat shock, electroporation, microprojectile bombardment, *Agrobacterium* mediated transformation using co-integrate or binary vector systems)
Unit – V
PCR (including RT and Real-time PCR)
Site-directed mutagenesis (Principles, generation of mutants, significance)
RFLP, AFLP, VNTRs
DNA microarray
Practical based on Units I – V

Suggested Readings:

1. Molecular Biology of the Cell, B. Alberts, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter, 6th edition, 2014, Norton and Company.
2. Molecular Biology of the Gene, J.D. Watson, 7th edition, 2017, Pearson India Education.

3. Cell and Molecular Biology, P.K. Gupta, 2005, Rastogi Publications.
4. Molecular Cell Biology, H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretcher, H. Ploegh, P. Matsudaira, 6th edition, 2007, W.H. Freeman.
5. Molecular Biology and Genetic Engineering, P.K. Gupta, 2005, Rastogi Publications.

M.Sc. MICROBIOLOGY (SEMESTER - II)
MIC-CC-203: PLANT VIROLOGY
4 Credits/40 Hours

Course Outcomes:
After completion of the Course, the student will:

- Understand the basic principles of virology, and the structural diversity of plant viruses.
- Understand the genetic diversity of viruses and the contrasting replication strategies of viruses possessing an RNA or a DNA genome.
- Learn about the transmission characteristics of the viruses at the molecular level, and understand the genetic basis of host responses to virus infection.
- Understand the concept of sub-viral pathogens, and methods of plant virus control, both conventional and modern.
- Understand the biology of viroids, and study symptomatology and pathology of diverse plant viruses.

Unit – I
Development of the science of virology
Nomenclature and classification of plant viruses (Criteria, International Committee on Taxonomy of Viruses, classification)
Structural components
Particle morphology (Helical, icosahedral, bacilliform, geminate)
Unit – II
Genome diversity and genome organization in TMV, BMV, CaMV, SYNV, TSWV, geminivirus
Genome expression strategies
Replication of Tobacco mosaic virus (RNA virus)
Replication of Cauliflower mosaic virus (DNA virus)
Unit – III
Symptoms of virus-infected plants (morphological, anatomical, physiological)
Gene for gene hypothesis, host responses, hypersensitivity, sensitivity
Modes of transmission (Mechanical, vegetative, graft, dodder, seed and pollen, nematodes, insect)
Molecular mechanisms of insect vector transmission (Externally borne, internally borne, examples potyvirus, caulimovirus, luteovirus)
Unit – IV
Conventional methods of plant virus control
Modern methods of plant virus control (Cross protection, satRNA-mediated, pathogen-derived resistance, R-gene mediated, PGPR-mediated, IPM)
Satellite RNA
Hepatitis delta virus (general account)
Unit –V
Disease cycles of TMV, CMV, PRSV, geminivirus
Viroids (Structure, classification, replication, pathogenicity)
Practical based on Units I –V

Suggested Readings:

1. Matthew's Plant Virology, R. Hull, 4th edition, 2003, Elsevier.
2. Plant Pathology, G.N. Agrios, 5th edition, 2005, Elsevier.
3. Applied Plant Virology, D.G. Walkey, 2nd edition, 1991, Springer.
4. Handbook of Plant Virology, J. Khan and J. Dijkstra, 2006, CRC Press.
5. Comparative Plant Virology, Roger Hull, 2nd edition, 2009, Academic Press.
6. Basics of Plant Virology, H.N. Verma, 2003, IBH.

M.Sc. MICROBIOLOGY (SEMESTER - II)
MIC-CC-204: ENVIRONMENTAL MICROBIOLOGY
4 Credits/40 Hours

Course Outcomes:
After completion of the Course, the student will:

- Understand biomes, ecosystems, ecological pyramids and trophic levels in food chains and food webs.
- Learn about the diversity of microbes in aquatic environments, factors affecting their growth, and water-borne diseases caused by infectious microbes.
- Understand the concept of oxygen demanding wastes through BOD and COD, water pollution and its remediation, and waste management.
- Define remarkable role of microbes in cycling of nutrients, and study species interactions and associations in soil affecting physiology and growth of plants.
- Learn about microbes thriving in harsh environments, microbial blooms and their adverse effects, and methods of sampling air borne microbes.

Unit – I
Biosphere
Ecosystem (General principles, components)
Energy transfer
Food chain
Unit – II
Microbial populations in natural water (marine and fresh-water)
Factors affecting growth in aquatic environments (temperature, salinity, light, pH, hydrostatic pressure, dissolved oxygen, inorganic nutrients, organic matter)
Purification of drinking water
Water borne diseases (Hepatitis A, poliomyelitis, cholera, gastroenteritis)
Unit – III
Sources of water pollution, Indicator microorganisms
Waste water treatment
Solid and liquid-waste treatment
Biological waste water management, BOD, COD.
Unit – IV
Soil microbes and rhizosphere bacteria (plant growth promoting rhizobacteria)
Microbial interactions in soil (mutualism, commensalism, parasitism, predation, competition)
Mycorrhiza (Arbuscular mycorrhiza, Ectomycorrhiza)
Nitrogen and Sulphur cycles
Unit –V
Microbes in extreme environments
Algal blooms, Biofilms.
Sampling of microbes in air (passive monitoring, active monitoring by impingers, impactors)
Practical based on Units I – V

Suggested Readings:

1. Environmental Microbiology, R.M. Maier, I.L. Pepper, C.P. Gerba, 2000, Academic Press.
2. Microbial Ecology: Fundamentals and Applications, R.M. Atlas and R. Bartha, 4th edition, 1998, Pearson India Education.
3. Elements of Ecology, T.M. Smith and R.L. Smith, 8th edition, 2012, Pearson India Education.
4. Environmental Microbiology, R.G. Buckley, 2019, CBS Publishers.
5. Fundamentals of Ecology, E.P. Odum and G.W. Barrett, 5th edition, 2005, Cengage Learning.

M.Sc. MICROBIOLOGY (SEMESTER - II)
MIC-204: MEDICAL MICROBIOLOGY AND IMMUNOLOGY
4 Credits/40 Hours

Course Outcomes:
After completion of the Course, the student will:

- Understand pathogenesis and the role of toxins, enzymes and host factors in infection and disease.
- Know about diseases caused by diverse microorganisms with emphasis on emerging diseases and pandemics.
- Learn about the oncogenic viruses and cell transformation, and understand the importance of antimicrobial agents and drug resistance.
- Get an overview of immunology with a detailed account of molecular and cellular interactions that control innate and adaptive immunity.
- Understand the concept of autoimmunity, hypersensitive and allergic responses of the host and to learn methods of inducing immunity against the pathogen in the host.

Unit – I
Koch's postulates, host-microbe relationship and infection process
Kinds of disease, disease syndrome, disease transmission
Nature of virulence: Toxins (cholera, diphtheria, tetanus)
Nature of virulence: antiphagocytic factors, extracellular enzymes
Unit – II
Diseases caused by bacteria (*Staphylococcus*, *Mycobacterium*, *Salmonella*)
Diseases caused by viruses (Influenza virus, HIV)
Diseases caused by fungi (*Candida albicans*, *Trichophyton*, *Aspergillus*)
Diseases caused by protozoa (Amoeba, *Plasmodium*, *Trypanosoma*)
Unit – III
Cell-mediated/innate immunity (macrophages, phagocytosis, pathogen-associated molecular patterns, toll-like receptors, Cytotoxic lymphocytes, NK cells)
Inflammation, neutrophils, cytokines
Humoral/adaptive immunity (B and T-cells, T-cell receptors, MHC molecules and antigen processing and presentation, B-cell differentiation and antibody production)
Antibodies (basic structure, effector functions, major classes of antibodies), complement and its activation (classical, alternative, lectin pathways)
Monoclonal antibodies (Clonal selection theory, MAB technology, applications)
Unit – IV
Hypersensitivity
Allergy and allergens
Artificial immunity to infectious diseases through active and passive immunization, classification of common vaccines (antigenic preparations, live attenuated, killed vaccines, toxin-based vaccines, conjugate vaccines, DNA vaccines)
Autoimmune disorders
Unit – V
Oncogenic viruses
Antibody-antigen reactions (Interaction, precipitation reactions, agglutination reactions, ELISA, immunoblot, immunoelectron microscopy)
Antibiotics and their mode of action
Practical based on Units I –V

Suggested Readings:

1. Microbiology with Diseases by Taxonomy, R.W. Bauman, 4th edition, 2017, Pearson India Education.
2. Review of Medical Microbiology and Immunology, W. Levinson, 2016, MGH.
3. Kuby Immunology, J. Punt, S. Stranford, P. Jones, J.A, Owen, 8th edition, 2018, W.H. Freeman.
4. Roitt's Essential Immunology, P.J. Delves, S.J. Martin, D.R. Burton, I.M. Roitt, 13th edition, 2017, Wiley-Blackwell.

M.Sc. MICROBIOLOGY (SEMESTER - III)
MIC-CC-301: MICROBIAL BIOTECHNOLOGY AND BIOINFORMATICS
4 Credits/40 Hours

Course Outcomes:
After completion of the Course, the student will:

- Learn the protocols for production of valuable pharmaceutical products utilizing microbes and recombinant DNA technology.
- Understand the role of microbes in food industry, development of GMOs and the related concerns, and application of microbes in improving soil fertility.
- Learn about the impact of microbes on habitat modification, microbial mining, and biodegradation of harmful waste.
- Understand the basic statistical concepts of population size, sample design, sampling methods and the significance of the results emerging from data analysis.
- Learn how to determine correlation and understand standard deviation
- Learn how to fetch and align amino acid and nucleotide sequences and correlate it with molecular phylogeny.
- Learn to explore the biological databases for protein and nucleotide sequences

Unit I
Production of insulin and vaccines (including recombinants)
Production of recombinant interferon
Production of antibiotics (Penicillin, streptomycin)
Single cell protein
Microbes in relation to Biofuels, Biopolymers, Beverages (tea, coffee, beer, wine)
Unit II
Biofertilizers
Biopesticides, BT cotton (Technology, concerns)
Microbial Biosensors
Microbial utilization in mining and textile
Unit III
Microbes in Bioremediation
Bioaccumulation and metal scavenging by microbes
Environmental cleanup of Petrol, diesel and by-products by microbes
Biodegradation of xenobiotics and toxic waste
Concerns about use of GM food and GM technology
Unit IV
Population size, Sampling design, Sampling methods (Random, non-random)
Departure from normality
Positive and negative correlations, regression
Relationship between curve area and standard deviation
Tests of significance (Chi-square test, Students t-test, F-test)
Unit V
Biological databases (General account)
Sequence alignment and database searching
Evolutionary concepts based on sequences
BLAST, FASTA, EMBOSS
Multiple sequence alignment by CLUSTAL W
Practical based on Unit I-V

Suggested Readings:

1. Basic Biotechnology, C. Ratledge and B. Kristiansen, 2nd edition, 2001, Cambridge University press.
2. Introduction to Biotechnology, Thieman and Palladino, 3rd edition, 2013, Pearson Education India.
3. Crueger's Biotechnology-A textbook of Industrial Microbiology, V.B. Rastogi and K.R. Aneja, 3rd edition, 2017, Scientific International Pvt. Ltd.
4. Biotechnology, E. Daugherty, 2014, Scientific International Pvt. Ltd.
5. Methods in Biostatistics, B.K. Mahajan, 7th edition, 2010, JPB.
6. A textbook of Biostatistics, B. Annadurai, 2017, New Age International.
7. Discovering Genomics, Proteomics and Bioinformatics, Campbell, 2nd edition, 2007, Pearson India Education.
8. Bioinformatics: Methods and Applications, Genomics, Proteomics and Drug Discovery, S.C. Rastogi, N. Mendiratta, P. Rastogi, 4th edition, 2013, Prentice Hall India.

M.Sc. MICROBIOLOGY (SEMESTER - III)
MIC-CC-302: INDUSTRIAL AND FOOD MICROBIOLOGY
4 Credits/40 Hours

Course Outcomes:
After completion of the Course, the student will:

- Understand industrial fermentation, manipulation of microbial strains, and techniques for producing optimal product.
- Learn about diseases caused by contaminated food stuffs and the lab tests for detecting the causal microorganisms.
- Learn of the valuable products obtained from industrially important microbes.
- Know about the ubiquitous presence of microbes, hence contamination of food items and food spoilage, and factors affecting their growth.
- Know the physical and chemical techniques utilized worldwide in food preservation.

Unit – I
Suitability of microbes in industrial processes and their source
Fermentation
Recovery and purification of fermentation products
Strain improvement
Product optimization
Unit – II
Alcohol and alcoholic beverages
Organic acids (citric, lactic, acetic)
Amino acids (glutamine, lysine, tryptophan)
Enzymes (amylase, protease, pectinase)
Vitamins (B_{12}, riboflavin)
Unit – III
Diversity of microbes in food (contamination with airborne bacteria, fungi, contamination with microorganisms present in soil, water, plants, skin, etc.)
Factors affecting growth of microorganisms in food (intrinsic factors such as pH, nutrient content, antimicrobial constituents, water activities and extrinsic factors such as temperature, relative humidity, atmospheric gases, etc.)
Spoilage of food products
Unit – IV
Food preservation by heat (pasteurization, appertization, D value, microbial heat resistance), preservation by low temperature (chilling, freezing)
Preservation by radiation (microwave, UV, ionizing)
Preservation by chemical additives and canning
Unit – V
Food borne diseases (Salmonellosis, Staphylococcal intoxication, Botulism, Enteropathogenic *E. coli*)
FDA, FSSAI, Lab testing procedures
Immobilized enzyme technology
Practical based on Units I – V

Suggested Readings:

1. Food Microbiology, W.C. Frazier and D.C. Westhoff, 2015, McGraw-Hill Education.
2. Food Microbiology, M.R. Adam and M.O. Moss, 2nd edition, 2018, New Age International Private Limited.
3. Food Microbiology and Technology, H.H. Weiser, 2018, Scientific International Pvt. Ltd.
4. Food Science, N.N. Potter and J.H. Hotchkiss, 5th edition, 2007, CBS.
5. Prescott and Dunns Industrial Microbiology, G. Reed, 4th edition, 2004, CBS.

M.Sc. MICROBIOLOGY (SEMESTER - IV)
MIC-SI-401: SEMESTER INTERNSHIP
24 Credits/ Full Semester

Course Outcomes:

The full semester Internship is designed to ensure that the student is able to apply the knowledge gained in the previous three semesters in specific areas of interest in a problem solving environment, gaining bench-experience, to serve as a springboard for a professional future.

Internship for Semester IV will be carried out by the students in various recognized/established labs of Other Universities, of Institutes under CSIR, ICMR, IIT, ICAR, DST, DBT, and of Industry etc. (to be arranged by the students themselves, including whatever expenses become due in this regard).