M.Sc. MICROBIOLOGY SYLLABUS
ASSAMUNIVERSITY
(Revised)

Syllabus prescribed for the degree of Master of Science in Microbiology as per UGC Model Curriculum. The following are the details for the Examination:

SEMESTER – I	**Max Marks**
Theory	
MIBCC 101: General Microbiology	100(70+30)
MIBCC 102: Mycology and Phycology	100 (70+30)
MIBCC 103: Virology	100 (70+30)
MIBCC 104: Microbial Physiology and Biochemistry	100 (70+30)
Practical	
MIBCC 105.General Microbiology and Analytical Biochemistry	100 (70+30)
Total 500	

SEMESTER – II	
Theory	
MIBCC 201 Cellular Microbiology and Immunology	100 (70+30)
MIBCC 202: Molecular Biology and Recombinant DNA Technology	100 (70+30)
MIBCC 203: *Basic and Applied Microbiology*(open choice)	100 (70+30)
MIBCC 204: Microbial EnzymeTechnology	100 (70+30)
Practical	
MIBCC 205: Immunology and Molecular biology	100 (70+30)
Total 500	

SEMESTER – III	
Theory	
MIBCC 301: Parasitology, Medical and Veterinary Microbiology	100 (70+30)
MIBCC 302: Food Microbiology	100 (70+30)
MIBCC 303: Microbial Genetics and Genomics	100 (70+30)
MIBCC 304: Bioinstrumentation and Bioinformatics	100 (70+30)
Practical	
MIBCC 305 Medical Microbiology and Bioinformatics	100 (70+30)
Total 500	

SEMESTER – IV

Theory

MIBCC 401: Soil and Environmental Microbiology 100 (70+30)

MIBCC 402: Elective / Optional paper

- Industrial Microbiology and Fermentation Technology
- Agriculture Microbiology
- Clinical Microbiology

100 (70+30)

MIBCC 403: **Dissertation*** 200

Practical

MIBCC 404: Environmental and Industrial Microbiology 100 (70+30)

*There are no internal marks for MB 403: dissertation. (Equivalent to two courses)

Total 500

Grand Total 2000

First Semester

Course no.	Course components	Name of the course	Semester	Lectures	Credits	Maximum marks	
						CIA*	External
MIBCC101	Core	General Microbiology	I	60	6	30	70
MIBCC102	Core	Mycology and Phycology	I	60	6	30	70
MIBCC103	Core	Virology	I	60	6	30	70
MIBCC104	Core	Microbial Physiology and Biochemistry	I	60	6	30	70
MIBCC105	Core	Generalmicro biologyandA nalytical Biochemistry	I	60	6	30	70
				Total	30	500	

Second Semester

Course no.	Course components	Name of the course	Semester	Lectures	Credits	Maximum marks	
						CIA*	External
MIBCC201	Choice based/ Open	Cellular Microbiology and Immunology	II	60	6	30	70
MIBCC202	Core	Molecular Biology and Recombinant DNA Technology	II	60	6	30	70
MIBCC203	Core	Basic and Applied Microbiology		60	6	30	70
MIBCC204	Core	Microbial Enzyme Technology	II	60	6	30	70
MIBCC205	Core	Immunology and molecular Biology	II	60	6	30	70
				Total	30	500	

Third Semester

Course no.	Course components	Name of the course	Semester	Lectures	Credits	Maximum marks	
						CIA*	External
MIBCC301	Core	Parasitology, Medical and Veterinary Microbiology	III	60	6	30	70
MIBCC302	Core	Food Microbiology	III	60	6	30	70
MIBCC303	Core	Microbial Genetics and Genomics	III	60	6	30	70
MIBCC304	Core	Bioinstrumentation and Computer Applications	III	60	6	30	70
MIBCC305	Core	Clinical Microbiology and Bioinformatics.	III	60	6	30	70
				Total	30	500	

Fourth Semester

Course no.	Course components	Name of the course	Semester	Lectures	Credits	Maximum marks	
						CIA*	External
MIBCC401	Core	Soil and Environmental Microbiology	IV	60	6	30	70
MIBCC402	Elective / Optional	-Industrial Microbiology and Fermentation Technology -Agriculture Microbiology -Clinical Microbiology	IV	60	6	30	70
MIBCC403	Project + Viva voce	Dissertation	IV	-	12	--	200
MIBCC404	Core	Environmental and Industrial Microbiology	IV	60	6	30	70
				Total	30	500	

FIRST SEMESTER

MIBCC101: General Microbiology 6 Credits **60 Lectures**

UNIT I: Classification of Micro-organism:History of bacterial classification. Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese; Basis of microbial classification, molecular approaches in microbial classification, concept of microbial species; Principle and classification of bacteria on the basis of *Bergey's manual of Determinative bacteriology*; Cyanobacteria and Prochlorons. **10 Lectures**

UNIT II: Morphology and fine structure of Bacteria**:** Morphological types – size, shape and arrangements; cell walls of archaea, Gram negative, Gram positive eubacteria, eukaryotes; L forms – cell wall synthesis, antigenic properties, cell membranes – structure, composition and properties. Reserve materials, inorganic and organic inclusions. **15 Lectures**

UNIT III: Structure and function of cell appendages and inclusions:capsule types, composition and function; flagella, fimbrae, pili, cilia, gas vesicles, chromosomes, carboxysomes, magnetosomes, phycobillisomes, nucleoid, plasmids (types of plasmids and function); Bacterial spores: Regulation of spore formation. **10 Lectures**

UNIT IV: Aerobic, anaerobic, shaking, static cultures, nutritional types, culture media, culture methods-pure culture techniques, Growth curve, generation time, synchronous, batch and continuous culture; Measurement of growth and factors affecting growth, Sterilization and disinfection- heat, UV radiation, ionizing radiation, filtration. Chemical disinfectants. **15 Lectures**

UNIT V: Microbial diversity and extremophiles: Microbial diversity, distribution ecological niche, abundance and density. Extremophiles – Psychrophiles, acidophiles, alkaliphiles, thermophiles, barophiles etc., non-culturable bacteria (Metagenomics). Methanogens, Methanotrophs and Methylotrophs. **10 Lectures**

Suggested books:

1. Microbiology by Lansing M Prescott, Donald A Klein, John P Harley, McGraw Hill
2. Principles of Microbiology by Ronald M. Atlas (1995), Amy Mc Cullen
3. Microbiology: Principles and Explorations by Jacquelyn Black
4. General Microbiology by Roger Y Stanier, John L Ingraham, Mark L Wheelis
5. Microbiology by Michael J Pelczar
6. Fundamental Principles Of Bacteriology A J Salle
7. General Microbiology by Power and Daginawala, Himalaya Publishing House,
8. Foundations in Microbiology by Kathleen park Talaro, McGraw Hill. science
9. Microbiology: An Introduction by Gerard J Tortora, Berdell R Funke, Christine L Case, Dorling Kindersley (india) Pvt Ltd
10. Microbiology by Stuart Walker, W B Saunders

MIBCC102: Mycology and Phycology 6 Credits 60 Lectures

UNIT I: History and development of mycology, structure and cell differentiation, Criteria for fungal classification: Habitat morphology and reproduction of Slime molds, oomycetes, Zygomycotina, Ascomycotina, Basidiomycotina, Mastigomycotina and Deuteromycotina

10 Lectures

UNIT II: Homothallism and Heterothallism, Hetrokaryosis, Sex hormones in fungi physiological specialization in fungi, fungal succession on decomposing litter Mycorrhiza - ectomycorriza, endomycorrhiza and vesicular arbuscularmycorrhiza. Role of Mycorrhiza in agriculture.Lichens.

10 Lectures

UNIT III: Fungi and Plant disease – Disease symptoms; the concept of virulence and resistance, mechanical and chemical barriers of infection, Study the pathogenesis symptom and control of following diseases: Early and late blight of potato; loose smut of wheat, false smut of paddy, Fusarial wilt, red rot of sugarcane.

15 Lectures

UNIT IV: Fungi and animal disease – Dermatophytes and agents of superficial mycoses. Yeasts of medical importance.Mycotoxins, antifungal agents.Dimorphic fungi causing systemic mycoses, Dimatiaceous fungi.Opportunistic hyaline hypomycetes, agents of zygomycosis, Fungi causing eumycoticmycetoma.Mode of actions of antifungal agents.

15 Lectures

UNIT V: Phycology – Distribution of algae, Classification of algae; thallus organization in algae; reproduction in algae; Brief account of Chlorophyta, Bacillariophyta; Phaeophyta; Rhodophyta; Algal ecology and algal biotechnology.

10 Lectures

Suggested Books:

1. TopleyAnd Wilson's Microbiology And Microbial Infections by Collier, Balows, Sussman. Edward Arnold.
2. Introductory Mycology by Constantine J. Alexopoulos
3. Text Book Of Medical Mycology by JagdishChander, Mehta Publishers, New Delhi
4. An Introduction to mycology by Mehrotra. New Age International.
5. Fungi: Diversity and Biotechnology by Rai.

MIBCC103: Virology 6 Credits 60 Lectures

UNIT I: General features, morphology of viruses -ultra structure, capsid and its arrangements, types of envelops and its composition; nomenclature and classification of viruses, Viral genomes, its type and structure; Viroids, virusoids , -brief details. prions – spread of prion diseases. Antiviral agents and interferons.

10 Lectures

UNIT II: Bacteriophages – Structural organization, multiplication cycle; eclipse phase, phage production, burst size, genetics of lytic and lysogenic cycle, bacteriophage typing, application in bacterial genetics; Application of bacteriophages in health – bacteriophage therapy.

08 Lectures

UNIT III: General methods of diagnosis and serology – Cultivation of viruses in animal inoculation, embryonated eggs, cell cultures and cell lines; Serological methods – haemagglutination, haemagglutination inhibition, complement fixation, immunofluorescent method, ELISA etc; Assay of viruses – physical and chemical methods (protein; nucleic acid and radioactive tracer, electron microscopy), infectivity assay (plaque method, end point method).

10 Lectures

UNIT IV: Plant viruses **–** Classification and nomenclature of plant viruses; Disease symptoms – histology, physiology and cytology of plants; common viral disease of paddy, tomato and sugarcane, Type species of plant viruses (e.g. TMV, Cauliflower mosaic virus and potato virus X), transmission of plant viruses & their preservation, diagnostic techniques (serological methods, histochemical tests and fluorescent microscopy).

12 Lectures

UNIT V: Animal viruses **–** classification and nomenclature of animal and human viruses; epidemiology, life cycle, pathogenicity, diagnosis, prevention and treatment of viruses; *RNA viruses*- Picornaviruses, Orthomixoviruses, Paramyxoviruses, Arthropod-borne viruses, Rhabdoviruses, Rotaviruses, HIV and other oncogenic viruses; *DNA viruses* – Pox viruses, Herpesviruses, Adenoviruses, Hepatitis viruses; Viral vaccines (conventional)

20 Lectures

Suggested Books:

1. Textbook of Virology by A J Rhodes. The Williams & Wilkins
2. Matthews' Plant Virology by Roger Hull, Elsevier
3. Understanding Viruses by Shors, J & B.
4. Principle of virology by Flint.
5. Clinical Virology Manual by Specter. ASM.

MIBCC104: Microbial Physiology and Biochemistry 6 Credits 60 Lectures

UNIT I: Amino acid; classification, chemical reaction, physical properties, primary, secondary, tertiary, and quaternary structure.Enzymes **–** Classification, multistep reaction and arate limiting steps, enzyme inhibition, mechanism of action. Kinetics of enzymes, allosteric, allosterism, kinetic analysis of allosteric enzymes, principles of allosteric regulation.

15 Lectures

UNIT II: Bioenergetics and strategy of metabolism **–** Strategy of energy production in the cell; oxidation – reduction reactions, coupled reactions and group transfer; standard redox potential, law of thermodynamics, entropy, enthalpy and free energy of reaction and ATP; spontaneity of reaction, G. G^0, G^1 equilibrium.

13 Lectures

UNIT III: Carbohydrate metabolism **–** Anabolism, catabolism, ATP (phosphorylation, oxidative phosphorylation, substrate level phosphorylation), electron transport; Metabolic pathways – Glycolysis, Pentose phosphate pathway, EntenerDoudoroff pathway, TCAcycle, Glycoxalate cycle.

12 Lectures

UNIT IV: Lipid and Nitrogen Metabolism **–** Oxidation of fatty acid (α, β, γ), Assimilation of nitrates, ammonia assimilation; amino acid biosynthesis – glutamate family, serine family, aspartate family, histidine biosynthesis – glutamate family, serine family, aspartate family, histidine biosynthesis.

10 Lectures

UNIT V: Bacterial photosynthesis–Characteristic ofPhotosynthetic bacteria, Phytosynthetic pigments; metabolism in Phytosynthetic bacteria; Phytosynthetic electron transport system; mechanism of photosysthesis, Dark reaction (Calvin-Benson cycle)

10 Lectures

Suggested Books:

1. Lehninger Principle of Biochemistry
2. Biochemistry by LubertStryer
3. Plummer, An introduction to practical Biochemistry
4. Biochemistry by Harper
5. Microbiology by Stuart Walker, W B Saunders

MIBCC105: General Microbiology andAnalytical Biochemistry (6 credits)

A: General Microbiology3 credits

1. Principle, operation and study of various components of microscope.
2. Examination of micro organism by micrometry.
3. Sterilization technique of glassware, material and culture media and preparation of culture plates and tubes.
4. Culture methods, pure culture preparation and subculturing technique.
5. Microbial growth measurement by direct cell count method, serial dilution method, turbidity method and standard plate count method.
6. Staining technique-simple, Gram's staining, negative staining, flagella staining, spore staining, Acid fast staining. Staining of Fungus.
7. Determination of bacterial motility
8. Isolation and identification of *Aspergillus, Penicillium, Fusarium, Alternaria, Nostoc, Anabaena, Oscillatoria, Microcystis.*
9. Isolation of actinomycetes from soil by dilution plate method.
10. Study of DNase, phosphatase and gelatinase activity by bacteria.
11. Culture of bacteriophage by double layer technique.

B:Analytical Biochemistry 3 credits

1. Preparation of buffer and chemical solutions and stains.
2. Principles of colorimetry, its calibration and estimation of O.D.
3. Separation of amino acids by paper chromatography.
4. Isolation of lipid from a given sample and its separation by TLC.
5. Determining of bacterial growth curve.
6. Effect of pH, temperature and chemicals on bacterial growth.
7. Study of factors affecting enzyme activity-substrate, temperature, pH.
8. Estimation of protein by Lowry method.
9. Estimations of reducing sugar by glucose by dinitro salicylic acid (DNSA method).

SECOND SEMESTER

MIBCC201:Cellular Microbiology and Immunology 6 credits 60 Lectures

UNIT I: Prokaryotic and eukaryotic signaling mechanism:Eukaryotic cell to cell signaling, endocrine signaling, prokaryotic signaling; quoram sensing and intercellular signaling,

08 Lectures

UNIT II: History and scope of immunology:Types of immunity – innate and acquired, passive and active. Physiology of immune response- Humoral and cell mediated immunity, Lymphoid organs. Immunohaematology of blood groups, ABO and RH compatibility.

10 Lectures

UNIT III: Antigens and Antibodies: structure and properties (types, iso and allo). haptens, adjuvants; antigen specificity; Immunoglobulins (antibodies) – structure, heterogeneity – types and subtypes, properties (physico-chemical and biological). Immunotoxins; vaccines and its types, toxoidsnational immunization programmes, newer generation vaccines

15 Lectures

UNIT IV: Antigen – Antibody reactions; agglutination, haemagglutination, precipitation, Complement fixation, immunofluorescence; enzyme linked immunosorbent assay (ELISA), radioimmunoassay.Hybridoma technology – monoclonal antibodies and its uses.

15 Lectures

UNIT V: Complement pathways. Hypersensitivity-anaphylaxis, cytotoxic reaction.Autoimmunity, Transplantation immunology and tumor immunology.HLA tissue typing, major histocompatibility complex.

12 Lectures

Suggested Books:

1. Immunology by Janis Kuby
2. Essential immunology by Roitt
3. Immunology: A short course by Eli Benjamini, Wiley.
4. Laboratory immunology& serology. Neville J. Bryant
5. Foundations in Microbiology by Kathleen park Talaro, McGraw Hill. Science

MIBCC202: Molecular Biology and recombinant DNA technology 6 Credits 60 Lectures

UNIT I: Organization of DNA in eukaryotic cell; palindromic DNA; Types of RNA-rRNA; mRNA (the 5' cap, non-coding region, initiation codon, coding region, termination codon; Poly (A) region, post transcriptional modification,differences between prokaryotic and eukaryotic mRNA; tRNA (structure of tRNA-clover leaf model); superhelicity in DNA.Dispersive, conservative and semi-conservative models; Watson and Crick's model of DNA replication (experimental evidence); Enzyme involved in DNA replication (DNA polymerase I, Pol II, Pol III, DNA ligase); Mechanism of DNA replication; Models of DNA replication, inhibitors of DNA replication.Exonuclease and endonucease.

20 Lectures

UNIT II: Gene diversity; split genes, overlapping gene; molecular nature of mutation, spontaneous and induced mutation; DNA damage and repair – types of damage (deamination, oxidative damage,

alkylation, pyrimidine dimmers); repair pathways – methylation – directed mismatch repair, nucleotide excision repair, base excision repair, recombination repair, SOS repair.

10 Lectures

UNIT III: Central dogma; RNA polymerase; Site of transcription. Transcription – chain initiation, chain elongation, chain termination, RNA turn over; translation – charging of tRNA, initiation of polypeptide synthesis, elongation of polypeptide chain, translocation, termination of polypeptide chain;

10 Lectures

UNIT IV: Cloning vectors **–** Plasmids, phages and cosmids, phagemids, Ti plasmids, other viral vectors (M13 and retroviruses); Cloning strategies, cloning and selection of individual genes; Gene libraries– cDNA and genomic libraries. Expression vectors, promoter probe vectors, vectors used for construction of library – artificial chromosomes; BAC vectors, YAC vectors.

12 Lectures

UNIT V: Working principle of PCR, requirements, types of PCR, application of PCR, Sequencing of DNA and protein in brief. Recombinant products – human growth hormone (insulin somatotropin), vaccines (hepatitis B virus vaccine, FMD vaccine), interferons, tPA.

08 Lectures

Suggested Books:

1. Molecular Genetics of Bacteria: Snyder &Champness
2. Molecular Biology by Freifelder
3. Genomes 3: T. A. Brown
4. Principles of gene manipulation by Old and Primerose
5. Topic related recent review articles

MIBCC203: Basic and Applied Microbiology 6 Credits 60 Lectures

UNIT II: Introduction to Microbial Diversity. Defining microbial diversity: a changing paradigm. Large scale evolution: The Big Tree. Molecular characterization of organisms.Overview of phylogenetic diversity.Principal of molecular phylogeny Methods in Taxonomy of Bacteria, Archaea and Fungi morphological Methods Chemotaxonomy. Genetic Methods Methodology of rRNA sequencing.

10 Lectures

UNIT II: Methodology of identification of unknown pure cultures: Strategy and methods Diversity The expanse of microbial diversity, estimates of total number of species, measures and indices of diversity. Newer approaches for exploring unculturable bacteria from environmental samples like sewage. Culture independent molecular methods.

10 Lectures

UNIT III: Emerging infectious diseases and microbial health hazards. Swine flu, Bird flu, Rabies, HIV, Hepatitis B and Ebola virus infections.Emerging communicable bacterial diseases (Plague, Anthrax). Opportunistic parasitic infections in immunocompromised patients.

15 Lectures

UNIT IV: Waste utilization: Waste water treatment - Aerobic and Anaerobic processes, Treatment schemes for waste waters of dairy, distillery, tannery, antibiotic industries. Sewage disposal, compost

making, methane generation. Microbiology of degradation of xenobiotics in environment: hydrocarbons, oil pollution, surfactants, pesticides, Microorganism for waste treatment.

10 Lectures

UNIT V: General concepts of microbial biotechnology. Microorganisms as factories for the production of novel compounds, Nature of microbial polysaccharides, mechanism of synthesis; Biopolymers and bioplastics, Bioprocess technology, beer brewing, cheese manufacture, mold–modified foods, Wine, Vinegar, The fermentation process, procedure and equipments, Ideal bioreactors, Batch, fed batch, CSTR, PFR, Multiphase bioreactors, packed bed, bubble column fluidized trickle bed, immobilization. Aseptic, septic and anaerobic fermenters.

15 Lectures

Suggested books:

1. Barnett, H. L. and Hunter, B. B. 1960. Illustrated Genera of Imperfect Fungi.Burgess Publishing Co., Minnesota.
2. Breed and Buchanan. Bergey's Manual of Systematic Bacteriology. 2nd Edition, (Volumes. 1 – 5) (2001 – 2003).
3. Cook T. (2002) Microbial Biodiversity: Saving Bacteria to save ourselves, Harvard Science Review, 26-28.
4. Keller M. and Zengler K. (2004) Tapping in to Microbial Diversity. Nature Reviews 2, 141-150.
5. Pace N. (1997) A Molecular View of Microbial Diversity and the Biosphere, Science, 276, 734-740.
7. Industrial Microbiology by Casida.
8. Industrial Microbiology by Cruger&Cruger.
9. Principles of Fermentation Technology. Stanbury Pf, Whitaker A, Hall Sj. Elsevier India P Ltd.
10. Topic related recent review articles.

MIBCC204: Microbial and Enzyme Technology 6 credits 60 Lectures

UNIT I: Enzymes from microbial sources, large scale production of enzymes, recovery of enzymes, enzyme purification methods - enzyme precipitation, separation by chromatography

15 Lectures

UNIT II: Immobilized enzymes: Physical and chemical methods of immobilization, Enzyme catalysis in apolar medium, reverse micellar entrapment of enzymes and its applications.

10 Lectures

UNIT III: Application of enzymes: synthesis of chemicals using enzymes, food technology and medicine. Enzymes in diagnostic assays. Enzyme electrodes, immunoenzyme techniques

10 Lectures

UNIT IV: Commercial products of microbes: Antibiotics, biopolymers, biosensors, biopesticides, Production of biofuels.

10 Lectures

UNIT V: Microbial toxins: Types, biochemical and molecular basis of toxin production, implications. Genetically engineered microbes, anti-HIV, anticancer, antifungal, antiplasmodial, anti-inflammatory compounds.

15 Lectures

MIBCC205: Immunologyand Molecular Biology (6 credits)

A: Immunology3 credits

1. Determination of blood groups and Rh factor.
2. Demonstration of agglutination reactionwith reference to, widal test
3. Demonstration of precipitation with reference to VDRL.
4. Demonstration of haemagglutination with reference to *Treponemapallidum*Haemagglutination test.
5. Demonstration of ODD (Ouchtlerlony Double Diffusion).
6. Separation and characterization of serum by serum electrophoresis method.
7. Demonstration of Antigen Antibody reaction by Counter current Immunoelectrophoresis and Rocket electrophoresis.
8. Separation and characterization of lymphocytes from blood.
9. Demonstration of Antigen antibody reaction by ELISA.

B: Molecular Biology 3 credits

1. Demonstration of replica plating technique.
2. Determination of expression of betagalactosidase in *E. coli.*
3. Isolation of antibiotic resistant *E. coli* by gradient plate method.
4. Demonstration of mutagenesis in microorganisms.
5. Isolation of plasmid from given bacterial sample.
6. Isolation of genomic DNA from bacteria.
7. Separation of DNA byagarose gel electrophoresis.
8. Separation of DNA by Native PAGE and separation of protein by SDS PAGE
9. Restriction digestion of bacterial DNA.
10. Estimation of DNA by diphenyl amine method.
11. Demonstration of Western, Southern and Northern blotting techniques.

THIRD SEMESTER

MIBCC301: Parasitology, Medical and Veterinary Microbiology 6credits 60 Lectures

UNIT I: Introduction to medical parasitology-classification. Pathogenesis, transmission, life cycle, lab diagnosis, treatment of Protozoa-*Entamoeba, Toxoplasma, Cryptosporidium,Leishmania, Trypanosoma, Plasmodium, Giardia, Trichomonas* and *Balantidium*.

10 Lectures

UNIT II: Discovery of pathogenic micro-organisms; normal microflora of human body; role of resident flora.Host-parasite relationships, Infection, type and source.Disease cycle (sources of diseases, reservoirs, transmission of pathogens); Intoxications (exotoxins and endotoxins and their mechanism of action).Antimicrobial agents and antibiotics: Antiseptics, chemotherapeutic agents, effect of antibiotics on protein, nucleic acid, cellwall and cytoplasmic membrane.

10 Lectures

UNIT III: Morphology, classification, cultural characteristics, pathogenicity and laboratory diagnosis of Staphylococci, Streptococci, Pneumococci, Neisseriae(Gonococci and Meningococci), *Haemophilus, Bordetella, Corynebacterium, Clostridium.*

12 Lectures

UNIT IV: Study of Enterobacteriaceae (*E. coli, Klebsiella, Salmonella, Shigella, Proteus*), Vibrios and Nonfermenting Gram negative bacilli. Emerging communicable diseases (Plague, Anthrax) - symptom, identification, monitoring and surveillance and quarantine administration.

13 Lectures

UNIT V: Introduction to *Mycobacteria, Brucella, Listeria, Pasturella*and Erysepelas. Spirochetes, *Rickettsiae, Chlamydia, Mycoplasma* and *Ureoplasma.*

15 Lectures

Suggested Books:

1. Text Book Of Medical Mycology by JagdishChander, Mehta Publishers, New Delhi
2. Sherris Medical Microbiology : An Introduction to Infectious Diseases by Kenneth Ryan, McGraw-Hill Medical
3. Jawetz, Melnick, &Adelberg's Medical Microbiology (Lange basic), McGraw-Hill Medical
4. Medical Microbiology by Patrick R. Murray, Michael A. Pfaller, & Ken S. Rosenthal, Elsevier
5. Text book of microbiology by Ananthanarayan and Paniker
6. Medical Microbiology by Cedric Mims, John Playfair and Ivan roitt. Mosby-wolfe

MIBCC302: Food Microbiology 6 credits 60 Lectures

UNIT I: Micro-organisms and their importance in food microbiology – molds, yeast, bacteria, general features, classification; principles of food preservation; asepsis – control of micro-organisms (anaerobic conditions, high temperature, low temperature, drying); factors influencing microbial growth in food – extrinsic and intrinsic factors; chemical preservation and food additives; canning process for heat treatment.

15 Lectures

UNIT II: Contamination and Spoilage **–** Cereals, Sugar products, vegetables, fruits, meat and meat products; milk and milk products, fish and sea food, poultry spoilage of canned food; detection of spoilage and characterization.

10 Lectures

UNIT III: Food-borne infections and intoxications – bacterial:*Brucella, Bacillus, Clostridium, Escherichia, Shigella, Staphylococcus, Vibrio, Yersinia*and non-bacterial intoxication (with examples of infective and toxic types) –Protozoa, algae, fungi and viruses; food borne outbreaks – laboratory testing procedures, preventive measures, GMP and Hazard Analysis and Critical Control Point. Food control agencies and its regulations; Employee's health standards, waste treatment, disposal and quality control.

15 Lectures

UNIT IV: Food fermentation–Bread, vinegar, fermented vegetables, fermented dairy products; experimental and industrial production methods; spoilage and defects of fermented dairy products; oriental fermented foods – its quality standard and control.

10 Lectures

UNIT V: Microbial cells as food (Single cell protein), mushroom cultivation; fermented beverages – beer and wine; steroid conversion – industrial enzymes, production of amylases, proteinases, cellulases, amino acid production – glutamic acid and lysine; pickles, olives, soy sauce, genetically modified (GM) foods.

10 Lectures

Suggested Books:

1. Food Microbiology by William C Frazier. Tata Mgraw Hill
2. Food Microbiology by dams and Moss. Springer Verlag
3. Basic food microbiology by Banwart. Cbs Publishers & Distributors Pvt Ltd.
4. Principles of Microbiology by Ronald M. Atlas (1995), Amy Mc Cullen
5. Fundamental Principles Of Bacteriology A J Salle

MIBCC303: Microbial Genetics and genomics 6 credits 60 Lectures

UNIT I: Gene transfer mechanisms- Bacterial transformation (detection of transformation, development of competence, mechanism of transformation, transfection); conjugation-effective contact and pilli in conjugation, F-factor, the conjugal transfer process; high frequency recombination (Hfr) strains; the order of chromosome transfer; formation of F prime (F'); transduction – generalized transduction; abortive transduction; specialized transduction.Sex duction.

10Lectures

UNIT II: Genetic recombination – Mechanism of recombination. General recombination (Holiday model); General conversion; site specific recombination; Transposable elements – Classes of transposable elements; nomenclature of transposable elements, insertion sequence (IS elements),

10 Lectures

UNIT III: Genetics of Bacteriophages – F – factors and their uses in genetic analysis, Col plasmid and colicins; cryptic plasmids, penicillinase plasmid, heavy metal resistance plasmids, degradative plasmids, Ti-plasmids and Ri-plasmids; bacteriphages – lytic phages (T4, T7), lysogenic phages (phage λ, ΦX 174).

10 Lectures

UNIT IV: Gene regulation – negative regulation – *E. coli lac* operon (structural, operator, promoter and repressor genes), Positive regulation – *E. coli trp* operon; Regulation by small molecules e.g. ppGpp and cAMP Post-translational processing (removal of *fmet* from polypeptide; ribosome editing: protein folding); Gene silencing (RNAi):An introduction and its application.

15 Lectures

UNIT V: Genomes: Size, physical structure, Whole genome shotgun sequencing, NGS (Next Generation Sequencing), General characteristics of bacterial genome, metagenomics. Functional genomics: Genome annotation, entire genome expression analysis-microarrays, expressed sequence tags (ESTs), serial analysis of gene expression (SAGE), Proteomics.

15Lectures

Suggested Books:

1. Microbial genetics by Freifelder
2. Gene Cloning by T A Brown
3. Principles of gene manipulation by Old and Primerose
4. Genes IX Lewin
5. Molecular Biology of the Gene: Watson et al

MIBCC304: Bioinstrumentation and Computer application 6 credits 60 Lectures

UNIT I Electrochemistry: pH and Buffers Potentiometric and Conductometric titration. Principal and application of Light, phase contrast, Fluorescence Scanning and Transmission electron microscopy, confocal microscopy, cytophotometry and flow cytometry, Preparation samples for microscopy.

10 Lectures

UNIT II Principle Methodology and applications of gel filtration, ion exchange and affinity chromatography, Thin layer and gas chromatography, High performance liquid chromatography, FPLC**,** Centrifugation: Basic principal and application, differential – density gradient and ultra centrifugation.

12 Lectures

UNIT III: Principle of biophysical method for analyzing biopolymer structure, X ray diffraction Fluorescence, UV ORD/CD Visible IR, NMR and ESR spectroscopy, Atomic absorption and plasma emission spectroscopy, MS and MALDI –TOF

15 Lectures

Unit IV: Electrophoresis, Principle and application of Native, SDS Agarose and 2D gel Electrophoresis.Blotting techniques – Southern blotting, Northern blotting, Western blotting.

10 Lectures

UNIT V: Biostatistics and bioinformatics – Mean, mode, median; Standard deviation and standard error; analysis of variance (ANOVA); correlation and regression analysis; Computer application - Computer basics, operating system – Windows, Hardware, Software; Internet – local area network, wide area network and computer application in microbiology.Overview of bioinformatics-NCBI, EMBL, PDB; homology algorithms (BLAST) and FASTA.

13 Lecture

Suggested Books:

1. Biochemistry by LubertStryer
2. Biostatistics A.nd Microbiology: A Survival Manual by Daryl S. Paulson. Springer Verlag
3. Sharma BK, Instrument method of chemical analysis
4. DA Skoog , Instrument method of analysis
5. Plummer, An introduction to practical Biochemistry
6. Chatwal and Anand, Instrumentation
7. Boyer, Modren experimental Biology

8. Principles and Techniques Of Biochemistry And Molecular Biology, Keith Wilson, John Walker. Cambridge University Press India Pvt. Ltd.

MIBCC305. Clinical Microbiology and Bioinformatics (6 credits)

A: Clinical Microbiology 3 credits

1. Examination of ova/cysts in faecal sample
2. Biochemical tests for identification of medically important organisms (Catalase, Oxidase, Indole, Methyl Red, VogesPrauskaeur, Citrate, Urease, Triple Sugar Iron and Sugar fermentation tests).
3. Isolation and Identification of *Escherichia coli, Klebsiella, Salmonella, Shigella, Proteus, Vibrio* and *Pseudomonas.*
4. Differentiation of staphylococci and streptococciby colony morphology and confirmatory tests.
5. Determination of Antimicrobial susceptibility by Stokes method, Kirby Bauer disc diffusion technique and Minimum Inhibitory Concentration (MIC) method.
6. Isolation of micro organisms from food samples.
7. Microbial examination of water (Coliform count) by MPN method.
8. Determination of milk quality by Methylene blue reduction test.

B:Bioinformatics 3 credits

1. Learning bioinformatics tools and techniques.
2. Preparation of chart, 3D diagram, bar diagram and line diagram using computer
3. Study of chromatographic techniques
4. Separation of macromolecules by electrophoresis
5. Sectioning and samples preparation for electron microscope
6. Analysis of biopolymer by spectroscopy
7. Demonstration of various blotting techniques

FOURTH SEMESTER

MIBCC401: Soil and Environmental Microbiology 6 credits 60 Lectures

UNIT I: Aero-microbiology - droplet nuclei, aerosol, assessment of air quality, brief account of air-borne microbes – bacteria, fungi, and viruses, their diseases and preventive measures; Phylloplane and Phyllospheremicroflora.

8 Lectures

UNIT II: Soil Microbiology – Classification of soil-physical and chemical characteristics, soil as a habitat for micro-organisms, microflora of various soil types, Rhizosphere and rhizoplane. Nitrogen fixation: Asymbiotic and symbiotic nitrogen fixation systems – root nodulation symbiotic bacteria (process of root nodule formation), Leghemoglobulin. Microbial interactions-symbiosis, mutualism, commensalisms, amensalism, competition, antibiosis;Actinorrhiza; Mycorrhizal fungi and its effect on plants.

12 Lectures

UNIT III: Production of biofertilizers and biopesticides – Quality control, BIS norms of biofertilizers; Biofertilizers (rhizobial inoculants, mass production and method of application); Biopesticides (viral, bacterial and fungal biopesticides); Biopolymers – Polyhydroxybutyrate (PHB), xantham gum.

10 Lectures

UNIT IV: Aquatic Microbiology – Water ecosystems – types, fresh water (pond, lakes), marine habitats (estuaries, deep sea, hydrothermal vents); Eutrophication, food chain; potability of water, microbial assessment for water quality, water purification, physical, chemical, microbiological characteristics of sewage.Characterization of solid and liquid wastes, physical, chemical and biological (aerobic, anaerobic – primary, secondary, tertiary) treatment; Solid waste treatment; Liquid waste treatment – trickling, activated sludge, oxidation ponds. Formation of biofilm.Biomagnifications.

20 Lectures

UNIT V: Role of microbes in environment – Organic matter decomposition, factors affecting litter decomposition; Biogeochemical cycling of C, N, P and S; Microbial biomass and soil fertility; Biodegradation of hydrocarbons and xenobiotics, Microbial leaching of iron and copper.

10 Lectures

Suggested Books:

1. Microbiology: Principles and Explorations by Jacquelyn Black
2. Soil Microbiology by SubbaRao. India Book House Pvt Ltd
3. Environmental Microbiology by Raina M. Maier, Ian L. Pepper, Charles P. Gerba. Academic Press
4. Fundamental Principles Of Bacteriology A J Salle
5. Topic related recent review articles

Elective/ Optional paper

MIBCC402: Industrial Microbiology and Fermentation Technology 6 credits 60 Lectures

UNIT I: Brief History of Industrial Microbiology, suitability of microbes in industrial processes and their sources types of fermentation and bioreactors, Recent development in industrial microbiology, structure of fermentor, Economic aspects of fermentation processes.

08 Lectures

UNIT II: Isolation, selection, improvement and maintenance of industrial important strain. Metabolic pathways and metabolic control mechanisms; primary metabolites (alcohols, vitamins, enzymes and organic acids) and secondary metabolites (antibiotics and toxins); substrates for industrial fermentation

15 Lectures

UNIT III: Batch culture in fermentation, growth kinetics of micro-organisms, classification of fermentation process; growth and nutrient, growth and product formation, heat evolution, effect of environment (temperature, pH, high nutrient concentration), media formulation and sterilization, kinetics of thermal death of micro-organisms.

12 Lectures

UNIT IV: Continuous culture and scale up – Continuous culture system, productivity, product formation, power requirement oxygen transfer kinetics, foam and antifoam-instrument control, physical and chemical environment sensors.

12 Lectures

UNIT V: Downstream processing objectives and criteria, foam separation Precipitation methods filtration devices industrial scale centrifugation and cell disruption methods. liquid -liquid extraction

solvent I recovery chromatography. Two phase aqueous extraction, super critical fluid extraction, ultrafiltration drying devices crystallization and whole broth processing, IPR and bioethics.

13 Lectures

Suggested Books:

1. Industrial Microbiology by Prescott and Dunn. Agrobios (India)
2. Industrial Microbiology: An Introduction. Michael J. Waites, Neil L. Morgan, Gary Higton. Wiley-blackwell
3. Industrial Microbiology by Patel. Macmillan Publishers India
4. Principles of Fermentation Technology. Stanbury Pf, Whitaker A, Hall Sj. Elsevier India P Ltd
5. Industrial Microbiology by Casida
6. Industrial Microbiology by Cruger&Cruger
7. Principles of Fermentation Technology. Stanbury Pf, Whitaker A, Hall Sj. Elsevier India P Ltd

MIBCC402: Agriculture Microbiology **60 Lectures**

UNIT I: Soil microorganisms in agro ecosystems: Types of microbial communities; soil microbial diversity: significance and conservation; effect of agricultural practices on soil organisms. Biological nitrogen-fixation: The range of nitrogen fixing organisms; mechanism of nitrogen fixation (biochemistry of nitrogenase); genetics of nitrogen-fixation; Rhizobium-Legume Association; Symplasmids, N2 fixation by non-leguminous plants.

15 Lectures

UNIT II: Chemical transformation by microbes: Organic matter decomposition, nutrient mineralization and immobilization; transformation of carbon and carbon compounds; availability of phosphorus, sulfur, iron and trace elements to plants; biodegradation of herbicides and pesticides. Biofertilizer: Mass cultivation of microbial inoculants; green manuring; algalization; Azolla.

10 Lectures

UNIT III: Microbial products and plant health: PGPR (plant growth promoting rhizobacteria); significance of mycorrhizae; toxin producing microbes (antibiotics, aflatoxin, etc.); microbial herbicides; biological control. Bioindicators – their relevance and utility; Measurement of Microbial activity in environmental samples; Microbial transport and bioaugmentatin.

15 Lectures

UNIT IV: Microorganisms and organic pollutants; Biodegradation, Bioremediation; Microorganisms and metal pollutants; Emerging Technologies in environmental microbiology and its application; Bioreporters, Biosensors, and Microprobes; Micobial Fuel Cell; Environmental Risk assessment of GMOs; IPRs.

10 Lectures

UNIT V: Microbial transformations: The carbon cycle, The Nitrogen cycle, transformation of phosphorus, sulphur, iron and other related transformations. Fossil fuels: coal, petroleum, natural gas, L.P.G., Introduction to Bio-fuels and energy scenario of India, Bio-diesel crops of India. In vitro technology and vegetative propagation of bio-fuel crops.

15 Lectures

Suggested Books:

1. Microbiology: Principles and Explorations by Jacquelyn Black
2. Soil Microbiology by Subba Rao. India Book House Pvt Ltd
3. Environmental Microbiology by Raina M. Maier, Ian L. Pepper, Charles P. Gerba. Academic Press

4. Fundamental Principles Of Bacteriology A J Salle

5. Topic related recent review articles

MIBCC402 Clinical Microbiology **60 Lectures**

UNIT I: Host pathogen interaction: The role of the microbial flora, Pathogenesis of infection: colonization and invasion. Role of microbiology laboratory in the diagnosis and control of infections. Management, safety and quality control in medical microbiology laboratory.

10 Lectures

UNIT II: Specimen collection and processing: Basic principles of specimen collection, preparation of container and swabs for collection of specimens for microbiological examination, preservation storage and transport of specimens, documentation of specimen. Microbiological examination of clinical specimens: Microscopic examination, use of colonial morphology for presumptive identification, biochemical identification of micro organisms. Immunodiagnosis of infectious diseases: Principles of immunological assays, use of serological testing in specific diseases (WIDAL, VDRL, TPHA, ASO, TORCH- profile, HBs ELISA, HIV- ELISA). Application of molecular diagnostics: Nucleic acid hybridization, nucleic acid amplification.

15 Lectures

UNIT III: Clinical syndromes and their laboratory diagnosis: Upper and Lower respiratory tract infections (Pharyngitis, otitis media, pneumonia), Skin and soft tissue infection (Impetigo, folliculitis, furuncle, carbuncle, cellulites and erysipelas), Infection of central nervous system (Meningitis and Encephalitis). Bacteremia and sepsis, Pyrexia of unknown origin (PUO).

15 Lectures

UNIT IV: Laboratory diagnosis of clinical syndromes: Gastrointestinal infection and food poisoning, Urinary tract infections, Sexually transmitted diseases, Infection in special populations (Malignancy, AIDS, Tuberculosis and leprosy). Zoonotic diseases-epidemiology, diagnosis, control and prevention.

10 Lectures

UNIT V: Epidemiology, surveillance and control of community and hospital infections. Antimicrobial chemotherapy, emergence of drug resistance (MRSA, ESBL and MDR TB). Methods of prevention and control- isolation of patients, quarantine and incubation period of various infectious diseases. Management of patients in infectious diseases hospital.

10 Lectures

Suggested Books:

1. Clinical Microbiology by Wiley B S Nagoba, Bi Publications Pvt Ltd
2. Manual of Clinical Microbiology by Patrick R. Murray, American Society Microbiology
3. Bailey & Scott's Diagnostic Microbiology by Betty A Forbes, Daniel F Sahm, Alice S Weissfeld. Mosby Year Book Inc
4. Sherris Medical Microbiology : An Introduction to Infectious Diseases by Kenneth Ryan, McGraw-Hill Medical
5. Jawetz, Melnick, & Adelberg's Medical Microbiology (Lange basic), McGraw-Hill Medical

MIBCC403: Project Work / Dissertation **12 credits**

I. Project Work Evaluation	150
II. Project Work Seminar	25
III. Project Viva Voce	25

I. **Project work evaluation:** The project work will be evaluated by both external and internal examiner based on experiment designed and thesis writing.

II. **Project work seminar:** Every student has to present their work under following subheadings viz. objective, methodology, results and conclusion.

III. **Project viva voce:** Viva voce will be conducted on the basis of project work and presentation.

MIBCC404: Environmental and Industrial Microbiology (Practical) (6 credits)

A: Environmental Microbiology 3 credits

1. Isolation and enumeration of bacteria and fungi from air samples by exposure plate method.
2. Isolation of micro-organism from rhizosphere and rhizoplane regions.
3. Isolation of *Rhizobia* from root nodule using Yeast Extract Agar Medium (YEMA).
4. Study of anatogonism of micro-organism by dual culture inoculation method (Bacterium Vs Bacterium; Bacterium Vs fungus; Fungus Vs Fungus).
5. Determination of BOD of water (Raw/Treated/Sewage).
6. Detection of dissolved oxygen (DO).
7. Isolation of bacteria from acidic and sodic (alkaline) soil.
8. Demonstration of salt tolerance level in bacteria.
9. Isolation of drought tolerant bacteria from soil

B: Industrial Microbiology 3 credits

1. Demonstration of working of fermentors and its components.
2. Batch fermentation of microbial enzymes/organic acids/antibiotics.
3. Microbial assay of vitamin B12 and streptomycin.
4. Production of wine from grapes using yeast.
5. Estimation of alcohol contents in fermented products.
6. Production and estimation of citric acid (using *Aspergillusniger*) by titerimetric method.

M.Sc in MICROBIOLOGY: COURSE OUTCOME AND COURSE OBJECTIVES

Sem	Paper Code	Paper	Outcome1	Outcome2	OBJECTIVE
1	MIBCC101	General Microbiology	Understanding of basics of microbiology and microorganisms	Understanding about history of microbiology	This course will provide basic information, in general about different types of microbes, and their significance.
1	MIBCC102	Mycology and Phycology	To understand morphology, classification, medical and economical importance of algae and fungi	To learn the role of algae and fungi in different environments, and their applications.	This course will make the learner informed about the eukaryotic microbes like fungus and algae for their role in environment and applications.
1	MIBCC103	Virology	To understand the structure and multiplication of viruses	To understand etiology, transmission, clinical syndrome, diagnosis, treatment and prevention of human virus infections	This course will enable the learner with detail information on viruses, their structure, and replication methods, along with disease pathology.
1	MIBCC104	Microbial physiology and biochemistry	To understand microbial physiology and metabolism.	To understand the diverse metabolic pathways in different microorganisms, that have significance in environment, health and industry.	This course will provide the basic principles of microbial physiological pathways and metabolic reactions, which will make the basis to apply this information in genetic engineering, or industry, environment, and health.
1	MIBCC105	General Microbiology and Analytical Biochemistry	Understanding of culture and growth characteristics of microorganisms, staining preparations and microscopical observations of microbes	To understand preparation buffer, chromatographic techniques, estimation of protein, sugar.	This course has objective to provide practical skills to the learners with focus on concepts and techniques learned in course 101, 102, 103 and 104.

2	MIBCC201	Cellular Microbiology and Immunology	To understand cell signaling mechanism, communications and interactions as cellular level between host and microbes.	To understand cellular details of immune system, immunity, and immunization	This course will enable the learner with details of interactions at cellular level. Interactions during microbial diseases and physiology at cellular level shall be useful to design novel methods for control and cure.
2	MIBCC202	Molecular biology and recombinant DNA technology	To understand macro molecule, protein synthesis and cloning strategies.	To learn and design strategy and methods for recombination techniques in DNA biology	This course will enable the learner to understand the concept of molecular biology of microbes, and also to design manipulative strategies on its basis for application in different area of biotechnology and microbiology.
2	MIBCO203	Basic and Applied Microbiology	To understand basic microbiology and important human pathogens	To learn pure culture methods of bacteria and metagenomics. To learn the benefits of the microbes, and their application in industry and environment	This is an open choice paper taken by students of other departments. Therefore it deals with basics of microbial world, harmful and beneficial roles of microbes. This course is designed so that students of other streams may understand microbiology and use it for interdisciplinary study.
2	MIBCC204	Microbial Enzyme Technology Microbial Enzyme Technology	To learn large scale enzyme production and recovery from microbial sources	To understand enzyme based diagnostic assays and immune enzyme methods.	This course will lead to understanding of the enzymatic mechanisms, regulation of activities, and their roles in industrial applications.

2	MIBCC205	Immunology and Molecular Biology	To learn isolation of DNA, RNA, separation of nucleic acid and protein.	Learning of antigen antibody reactions and various serological methods and assays for detection of infection. Immunological diseases	This course has objective to provide practical skills to the learners with focus on concepts and techniques learned in course 201, 202, 203 and 204.
3	MIBCC301	Parasitology Medical and Veterinary Microbiology	To understand medically important microbes, clinical condition and diagnosis. Bacterial, viral and fungal diseases and their greater details.	Learn the pathogenesis, cause and control of parasites.	This will enable the learner to deal with infectious disease and work in medical related industry/hospital set ups/research
3	MIBCC302	Food Microbiology	To learn importance of microorganisms in fermented food.	To understand food spoilage, contamination and prevention of spoilage, aong with food borne infections, food intoxications.	This course will provide technical expertise to the candidate to work in the area of food microbiology and allied industry.
3	MIBCC303	Microbial Genetics and Genomics	To learn Bacterial gene transfer mechanisms, gene regulations	To understand gene silencing and next generation sequencing.	This course provides the understanding of gene transfer mechanisms which will be useful in RDT research. The advance sequencing technologies for Genomic and metagenomic studies to understand and use the unculturable microbes is also envisaged.
3	MIBCC304	Bioinstrumentation and Bioinformatics	Learning of different instrumentation techniques and basics of bioinformatics	To learn basic mechanism and handling of sophisticated instruments used in industry and research.	This course will enable the students to handle sophisticated instruments.

3	MIBCC305	Clinical Microbiology and Bioinformatics	To learn cultural characterization and biochemical reaction based identification of bacteria.	To learn application of different software used from bioinformatics	This course has objective to provide practical skills to the learners with focus on concepts and techniques learned in course 301, 302, 303 and 304.
4	MIBCC401	Soil and Environmental Microbiology	To understand basics of aero, soil and aquatic microbiology.	To learn about plant microbe interaction, production of biofertilizer and biopesticide.	This course will enable the students to understand the role of microbes in environment, and its application for green agriculture and environment restorations.
4	MIBCC402 (elective)	Industrial Microbiology and Fermentation Technology	To understand industrially important microorganisms, primary and secondary metabolites.	To understand downstream processing, industrial processes for microbe-based commercial applications	This course will provide technical expertise to the candidate to work in the different microorganisms-based industry. Also, student will learn quality control and quality assurance of said processes.
4	MIBCC402 (elective)	Agriculture Microbiology	To learn about the role of microorganisms in enhanced production and yields of crops, PGPR and Mycorrhizae	To understand the significance of microbes for nutrient management in soil, degradation of agrochemicals, and in modern agriculture practices.	This course will provide the expertise on PGPR and Biofertilizers, which will be useful for green agriculture.
4	MIBCC402 (elective)	Clinical Microbiology	To learn about the management and practices of clinical microbiology lab. To have technical knowledge for diagnosis of different infections.	To have detail knowledge of different types of infections, chemotherapy and epidemiological concepts.	This course will provide the expertise on clinical microbiology related details with objective to place the student in clinical research or lab.
4	MIBCC404	Environmental and Industrial Microbiology	To learn isolation and enumeration of microorganism from soil and environment	To learn basic microbiological techniques used in industry	This course has objective to provide practical skills to the learners with focus on concepts and techniques learned in course 401 and 402.

4	MIBCC	Dissertation	To learn designing experiment, develop hypothesis and carry out research work in most relevant areas of microbiology	To learn about the research literature, research process, practice research methodology, writing thesis / scientific documents.	This course trains the candidate and provide the platform to take up higher research after successful completion of course.