

# M.Sc. Microbiology

Semester I (Total 25 credits): Course work- 17 credits, laboratory- 8 credits

## MB-701 : General Microbiology and Microbial Systematics (3 credits)

Microbiological techniques : Enrichment, pure culture, identification, Cultivation, preservation of microorganisms

Control of microorganisms : Sterilization methods, disinfection, sterility testing of substances

Ultrastructure of bacteria : Endospore, cell wall, flagella, cell membrane, pili, Capsule

Bacterial nutrition : Major and minor bioelements, nutritional diversity, oxygenic & anoxygenic, photosynthesis, respiration, fermentations, chemolithotrophy, syntrophy

Microbial systematics, evolution and biodiversity :

Classification of bacteria : GC content analysis and nucleic acid hybridization, 16S rRNA sequence based phylogeny. Archaeobacteria.

Origin of life: universal ancestor, origin of eukaryotic cells

## MB-702 : Medical Microbiology and Introductory Immunology- 1 (3 credits)

Host-Parasite relationship : Nonspecific host defenses, virulence factors, normal flora and gnotobiology

Epidemiology : Infectious diseases, disease cycle, epidemiological methods, diagnostic principles, control, prevention, antimicrobial therapy.

Bacterial diseases : Pathogenesis, diagnosis, prevention and treatment of diseases caused by *Staphylococcus*, *Streptococcus*, *Neisseria*, *Shigella*, *Salmonella*, *Mycobacteria*, *Treponema*

Immunology: History, cells and organs of the immune system.

Antigens types and properties. Antibody structure & function

Antigen-antibody interactions. Immunological techniques.

Organization and expression of immunoglobulin genes.

## MB-703 : Biochemistry- 1(4 credits)

Protein structure : amino acids, peptide bond, primary, secondary, tertiary and quaternary structure, determination of sequence, N-terminal & C-terminal analysis. Concepts of pH and buffer, chemical bonds.

Principles of Bioenergetics: Anabolism, catabolism, free energy, Laws of thermodynamics, Biological oxidation-reduction, high energy compounds.

Carbohydrate chemistry : structure, properties and classification, stereo chemistry, function of carbohydrates, storage polysaccharides etc.

Urea cycle

Lipid Chemistry & Metabolism

Vitamins: Fat soluble, water soluble and coenzyme form : biosynthesis, functions, reaction

Introduction to enzymes: classification, enzyme assays, purification.

## MB-704 : Introductory Molecular Biology & Genetic Engineering -1(4 credits)

Classical genetics : Mendel's Laws, Linkage & Complementation, Genetic Mapping

Gene expression in bacteria: Operon Concept, regulation of *lac*, *ara*, *trp* & *gal* operons.

Genetic engineering : Enzymes in DNA manipulation- Restriction-modification enzymes, ligases, polymerases etc. Vectors : plasmid, phage, cosmids, expression etc.

Basic techniques in Molecular biology and genetic engineering : Southern & Northern hybridization & preparation of labelled probes, DNA sequencing, PCR & Applications.

Cloning strategies-Library construction & screening of recombinant clones.

## MB-705 : Biohysics & Microbiology Microbiology (4 credits)

History of Microbiology

Microbiology of air and monitoring air pollution.

Aquatic Microbiology : Habitats and microbial communities, biofilms

Microbiology of water: Microbiological examination of water, indicator microorganisms, disinfection, purification processes.

Waste-water treatment : Characterisation of waste-water, self purification, conventional sewage treatment process, Microbiology of treatment plants, low cost plants and advances in treatment plants.

Pollutants and microbial interactions : Origin and dispersal of pollutants, types of pollutants-pesticides, hydrocarbons, surfactants, synthetic polymers, metals, monitoring pollutants. Biodegradation of representative pollutants and xenobiotic compounds.

Bioremediation Technology : bioremediation of soils and ground water, bioventing of petroleum hydrocarbons, bioremediation of oil spills. Environmental impact assessment

Microbial technology: Bioleaching, Biopesticides  
Study of techniques used for Biomolecules, UV, visible absorption spectroscopy, Fluorescence spectroscopy, circular dichroism.

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Semester II (Total 25 credits): Course work- 16 credits, lab- 8 credits, seminar- 1 credit,

**MB-801 : Microbial diversity and techniques (3 credits)**

Microscopy: General principles and optics of bright field, phase contrast, dark field, fluorescence, differential interference, microscopes etc.

Electron microscope & advanced microscopes (confocal laser scanning microscope, environmental scanning electron microscope)

Bacterial growth kinetics & measurements : methods of estimation, growth curve, factors affecting growth, batch, continuous and fed batch growth, synchronous growth,

Microbial physiology of diverse Groups

thermophiles, psychrophiles, halophiles  
Physiology and Biochemistry of nitrogen fixing bacteria.

Cyanobacteria

General characteristics of actinomycetes

Fungi and yeasts : classification , life cycle and cell structure.

**MB-802 : Medical Microbiology and Introductory Immunology II (3 credits)**

Mycoses : Superficial, Subcutaneous and systemic mycosis

Rickettsia, mycoplasma and chlamydia: general characteristics, pathogenesis, diagnosis, prevention and treatment of

Viral diseases : General characters, pathogenesis, diagnosis, prevention and treatment of diseases caused by Polio virus, Hepatitis, Rabies, Mumps, Influenza, Herpes, HIV

Protozoan diseases: Representative examples

Immunology: MHC complex. Antigen processing & presentation

Cell mediated immunity. Immune effector mechanisms: cytokines,

Complement system. Hypersensitivity.

Immune response to infectious diseases.

Vaccines and Monoclonal antibodies.

**MB-803 : Biochemistry-II (3 credits)**

Principles and applications of basic techniques : Electrophoresis, Centrifugation, and ultracentrifugation, Chromatographic techniques, Radioisotopes, X-ray crystallography.

Carbohydrate Metabolism : Glycolysis, gluconeogenesis, TCA cycle, ED pathway, HMP shunt - History, reactions, enzymes involved, regulation, distribution and energetics

Amino acids chemistry and metabolism : classification and properties

Elucidation of biosynthetic pathways, biosynthesis & catabolism of aromatic amino acids, branched amino acids, aspartate family, glycine, serine.

Purine-pyrimidine metabolism

**MB-804 : Introductory Genetics & Molecular Biology (4 credits)**

Introduction to yeast genetics. *Drosophila* , p elements

DNA structure and properties

Genetic code.

Gene expression in bacteria: Transcription, promoters and RNA polymerases

Introduction to bacteriophages : General characteristics and physiology of single stranded DNA phages and RNA phages, life cycles of T series phages

Lambda phage- Regulation of lytic and lysogenic cycles.

**MB-805 : Biostatistics & Applied Microbiology (3 credits)**

Microbial Ecology : microbial interactions, community structure and activity.

Methods: nucleic acid probes, radioisotopes, microelectrodes, community fingerprinting, microbial activity measurements. Microbial diversity indices.

Geochemical cycling: C, N, S, P, Fe cycles.

Plant pathology and plant defense

Biofertilisers

Dairy microbiology : microbiology of milk and milk products, cheese making.

Food microbiology : enumeration of microorganisms in food, preservation and spoilage, fermented foods, food borne, Infections, food

intoxications. Food flavors, Genetically modified foods.

IPR and Patents

Biostatistics : Distributions - normal, binomial and Poisson, mean variance, standard deviation and standard error. Coordination and regression; Test of significance; Analysis of variance

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### Semester III (25 credits)

#### Course work- 16 credits, laboratory- 8 credits, seminar- 1 credit

##### **MB-901 : Molecular Biology - I ( 4 credits)**

Genome organization in eukaryotes: chromosome structure and chromatin.

Mutations : Types of mutations, inheritance in bacteria, adaptive mutations, molecular basis of spontaneous lesions and induced gene mutations, suppressor mutations, reversions, site directed mutagenesis, mutations and disease

Eukaryotic Transcription : General features, enzymes & proteins in transcription machinery & regulation

Transposable genetic elements : prokaryotes - classification, IS elements, composite transposons, TnA family, mechanism of transposition

##### **MB-902 : Biochemical Engineering & Industrial Microbiology-I (3 credits)**

Fermentation principles : Different types of fermentative approaches, economics of fermentation, raw materials, design of mechanically & non-mechanically agitated fermenters, animal and plant cell cultivation.

Fermentation process : Screening of organisms and strain improvement. Downstream processes for fermentation product

Typical fermentations : Kinetics and fermentative production of antibiotics (penicillin, streptomycin), organic acids (citric acid), amino acids (glutamic acid, lysine), vitamins (B12), solvents (ethanol), recombinant DNA products

##### **MB-903 : Cell Biology & Enzymology-I (3 credits)**

Oxidative phosphorylation : Electron transport system in bacteria, mitochondria and chloroplast. Uncouplers and inhibitors, Theories of oxidative phosphorylation, ATPase – structure function

Photosynthesis in bacteria and plants : Organization, apparatus, electron donors and acceptors, energetics.

Organelle cell biology : Structure, function and biogenesis of chloroplast and mitochondria, mesosomes, lysosomes, cytoskeletal system.

Protein translocation in prokaryotes and eukaryotes: cytoskeleton, motor proteins

Eukaryotic cell division cycle: Mitosis, Meiosis, Cyclins, regulation of cell cycle

Enzyme kinetics : steady state kinetics, Michaelis-Menten equation, significance of kinetic constants, plots, single substrate kinetics, enzyme inhibition kinetics, two substrate kinetics, presteady state kinetics.

Protein engineering : General considerations, methodologies and significance

Immunology TCR, Thymic selection, T cell activation and differentiation,  $\gamma$ ,  $\delta$  T cells generation and function

##### **MB-904 : Microbial genetics and genomics (3 credits)**

Transduction : Generalized, restricted, linkage and mapping.

Transformation : Discovery, competence development, molecular mechanism of DNA uptake, mapping.

Conjugation : History, mechanism, Hfr transfer, linkage, mapping, F-plasmid and conjugative plasmids structure and function

Strain construction & problems in genetics.

Microbial genomics : Physical mapping, genome sequencing & annotation, functional genomics, transcriptome & proteome analysis, positional cloning, comparative genomics.

Techniques : RAPD, RFLP mapping, pulse field gel electrophoresis, FISH, microarrays, Mass spectrometry.

Yeast genetic engineering : vectors and cloning, yeast two hybrid system.

Bacterial vectors : Plasmids : Introduction, classification, incompatibility, copy number control & plasmids vector. Phage lambda as vector

##### **MB-905 : Microbial Physiology and Biophysics (3 credits)**

Microbial adaptation to stress : temperature, salt and oxidative stress.

Transport in prokaryotes : Types, methods of study, kinetics, transport of sugars, amino acids, organic acids, iron. Secretion systems in bacteria

Antibiotics : Biosynthesis, mode of action, regulation, genetics, hybrid antibiotics.

Protein folding and stability

## Semester IV (Total 25 credits)

Course work - 15 credits, laboratory 3 credits, seminar 1 credit, dissertation 4 credits, viva 2 credits

### **MB-001 : Molecular Biology –II (3 credits)**

DNA replication : General features, replication in prokaryotes- *E. coli* and phages, replication in eukaryotes – animal viruses, yeast and higher eukaryotes.

DNA repair : methods and mechanisms

DNA recombination : models and mechanisms

Eukaryotic Transcription & RNA processing : Post transcriptional modification, splicing, RNA editing, ribozymes.

Translation in prokaryotes & eukaryotes : Components of translational machinery, ribosome synthesis, functions of tRNA & rRNA, Initiation, elongation, termination of translation, post-translational modifications.

### **MB-002 : Biochemical Engineering & Industrial Microbiology II (3 credits)**

Fermentation process : Air sterilization, Media sterilization, aeration and mixing in bioreactors, approaches for production at larger scale, instrumentation, control.

Biotransformation of steroids

Microbial production of enzymes : amylases, proteases, glucose isomerases, penicillin acylases.

Immobilization of enzymes and cells : techniques and processes.

Biosensors.

### **MB003 : Cell Biology & Enzymology-II (3 credits)**

Membrane biology : Structure, function, isolation, membrane proteins

Transport in eukaryotes

Cell biology: cell junction and cell adhesion, extracellular matrix composition, diversity

Signal transduction in eukaryotes : MAP kinase pathway, G-proteins, protein kinases, Phosphoinositides

Immunology: Immune tolerance and autoimmunity, Leukocyte trafficking and inflammation. Chemokines and receptors

Enzyme kinetics : Mechanism of enzyme action : transition state theory, active site mapping. Case studies of chymotrypsin, lysozyme

Allostery. Hill, Adair, MWC, KNF models. Case studies of aspartate transcarbamylase, hemoglobin.

### **MB-004 : Microbial differentiation & Physiology (3credits)**

Phage genetics : Mutations & recombination in phages.

Microbial differentiation and regulation: Yeast mating types switching mechanism and regulation. Genetics of bacterial cell division. Genetics of sporulation in *Bacillus*. Genetics of *nod* and *nif* regulation in nitrogen fixation.

Bioinformatics : Introduction to internet resources & databases, analysis of biological data: sequence analysis, similarity search -BLAST, multiple sequence alignment- CLUSTAL W, phylogenetic analysis, protein structure analysis.

### **MB-005 : Bioinformatics & Molecular physiology (3 credits)**

Physiology of autotrophs & anaerobic respiration : autotrophic CO<sub>2</sub> fixation, hydrogen bacteria, nitrifying bacteria, sulphur bacteria, iron bacteria, methanogens.

Signal transduction prokaryotes : two component systems, chemotaxis, receptor structure & function. Quorum sensing (bioluminescence)

Molecular pathogenesis : Horizontal gene transfer; pathogenicity islands, type three secretory system, regulation of virulence genes, evolution of pathogen. Molecular pathogenesis of *Shigella*.

Cancer: characterization, retroviruses, oncogen, angiogenesis, therapy.

Advances in pathogenesis: malarial research & prions