# The Maharaja Sayajirao University of Baroda

## M.Sc BIOTECHNOLOGY SYLLABUS

**(Effective from July 2009 academic year)**

### M.Sc (Previous) Biotechnology [1st Year]

## Paper I - Microbial Diversity and Physiology

### Theory:

### Unit 1
Study of microorganisms: General characteristics and salient features related to structure, function, physiology and significance of cyanobacteria, actinomycetes, fungi, yeast, viruses, rickettsia, mycoplasma and chlamydia.

### Unit 2
Ultrastructure of a bacterial cell: spore, cell wall, flagella, cell membrane, capsule, pili.

Microbial growth: Batch, fed-batch, continuous kinetics, synchronous growth, yield constants; methods of growth estimation; stringent response; death of a bacterial cell.

### Unit 3
Microbial systematics and Molecular Taxonomy: GC content analysis, nucleic acid hybridization, 16S rRNA phylogeny. Origin of life; Archaebacteria.

Basic microbiological methods: Pure culture techniques; enrichment methods for specialised physiological groups. Microscopy – general principles and optics of conventional, advanced and specialized microscopes.

Microbial nutrition: Bioelements, nutritional diversity with respect to carbon and energy sources. Sterilisation, disinfection, safety in the microbio-logical laboratory

### Unit 4
Study of ecophysiological, biochemical and nutritional aspects of phylogenetically diverse representative groups of organisms: extremophiles - thermophiles, psychrofiles, halophiles, methanogens, archaebacteria, Nitrogen fixing organisms.

## Paper II - Immunity and Infection

### Theory:

### Unit 1
History and Terminology; Innate and acquired immunity; Antigen - antibody interaction; Techniques for measuring antibody response; Cells and organs
of the immune system; Antibody structure and function; Organisation and expression of immnoglobulin genes.

### Unit 2
MHC structure and function, antigen presentation; Cytokines, Complement system, Cell mediated immunity; Techniques; Inflammation and hyper-sensitivity; Immune response to infection

Vaccines and monoclonal antibodies, Immuno-deficiency

### Unit 3
Principles of virulence and pathogenicity; innate host defences; Host-parasite interaction; study of representative human diseases: bacterial, fungal rickettsial, mycoplasmal and protozoal; Principles of chemotherapy.

### Unit 4
Virology: classification, viral structure, replication and expression of selected viruses; Viral pathogenesis

## Paper III - Biochemistry

### Theory:

### Unit 1
Physical techniques and their applications in biology: UV/Visible spectroscopy, chromatographic techniques, electrophoresis, centrifugation and ultracentrifugation, radioisotope techniques, X-ray crystallography.

Concepts of pH and buffers. Basic bioenergetics, energy charge

### Unit 2
Amino acid metabolism. Building blocks of proteins. Properties of amino acids and their biosynthesis. Protein structure - primary, secondary, tertiary and quaternary. Basic enzymology

### Unit 3
Chemistry of carbohydrates; Metabolism of carbohydrates under aerobic and anaerobic conditions by different modes; anaplerotic pathway.

### Unit 4

Lipids: Chemistry of fatty acids, biosynthesis and degradation; biochemical roles of vitamins; chemistry and biosynthesis of purines and pyrimidines

## Paper IV - Introductory genetics and molecular biology:

### Theory:

### Unit 1

Basic genetics: Brief history; Mendel's laws; linkage, recombination, linkage mapping; complementation analysis. Mutations and their uses in genetic analysis. Genes in populations. Introduction to yeast genetics; *Drosophila* as a genetic system

### Unit 2

Gene structure and prokaryotic gene expression: DNA structure; The genetic code

Prokaryotic transcription - general features, structure & function of RNA polymerase, promoter parameters and specifications. Regulation of transcription: positive and negative regulation, attenuation. Operon models: *lac*, *ara*, *trp* and *gal* operons

### Unit 3

Introduction to phage genetics: Lysogeny and lytic cycle, replication and regulation of double stranded phages - λ as a model system

Introduction to genetic engineering: Enzymes used in recombinant DNA technology: restriction enzymes, ligases, polymerases etc. Plasmid and phage vectors

### Unit 4

Genetic Engineering: DNA labelling & hybridisation techniques: Nick translation, Northern and Southern blotting etc. DNA sequencing; PCR; construction and screening of libraries

## Paper V - Developmental Biology, Biophysics and Environmental Biotechnology

### Theory:

### Unit 1

Animal development: General principles and concepts; Developmental potential, determination and differentiation. Communication and signalling in development; Positional information and pattern formation; Morphogens in development; Induction and organizers;

Mesoderm induction and axis patterning in *Xenopus*

*Dictyostelium* as a developmental system: Signalling during aggregation, pattern formation in aggregates, cell movements and chemical signals, culmination

*Drosophila* development: Introduction to *Drosophila* development; Maternally acting genes and primary embryonic axes; Dorsoventral and anterior-posterior axis development; Segmentation genes - gap genes, pair - rule genes and segment polarity genes; Homeotic genes

### Unit 2

*Arabidopsis* as a model system for plant development; Introduction to genetic engineering of plants

Introduction to Neurobiology. Nerve cells, Properties of excitable membranes – resting potential, excitatory and inhibitory potentials, action potential. Voltage-gated channels. Chemical synapses, neurotransmitter release and post synaptic potentials. Modification of synaptic properties

Biostatistics: Distributions - normal, binominal and Poisson; Mean, variance, standard deviation and standard error; Coordination and regression; Tests of significance; Analysis of variance

### Unit 3

Intra and Intermolecular interactions; Structural determination and analysis of biomolecules: Absorption spectroscopy and other optical techniques like fluorescence, CD, infrared and Raman; Magnetic resonance spectroscopy

Size and shape of macromolecules; light scattering; analytical ultracentrifugation and other hydro-dynamic techniques; Structure analysis with electron rays. Thermodynamics, Irreversible thermo-dynamics; Biological energy conservation and energy transformation processes

### Unit 4

Applied and Environmental Biotechnology: Sewage and waste water management: Characterisation of waste water, conventional treatments, advances in aerobic and anaerobic treatment

Environmental pollution: types, origin, monitoring in air, water, soil; kinetics of biodegradation, bioremediation approaches. Applications of micro-organisms as insecticides, fertilisers, in ore leaching, in fermented milk and food products

# M.Sc (Final) Biotechnology [2nd Year]

## Paper I - Molecular Biology

### Theory:

### Unit 1
Genome organisation: Genome organisation in eukaryotes; Chromosome and nuclear architecture; Chromatin structure, regulation and modification; DNA methylation and imprinting; Epigenetics, histone modifications and their roles in gene regulation and cell memory

Mutation: Mutagenesis, physical and chemical mutagenesis; Types of mutations, chromosome aberrations.

### Unit 2
Eukaryotic transcription and RNA processing: Structure and function of eukaryotic RNA polymerases and their subunits: Pol I, Pol II and Pol III; general features of transcription; Transcription factors and DNA binding proteins
Post-transcriptional modifications of RNAs: poly adenylation, splicing of nuclear ribosomal RNA, nuclear mRNA, organelle RNA and tRNA; Role of maturases; RNA editing. RNA as a catalyst - the new age of RNA

### Unit 3
Translation in prokaryotes and eukaryotes: Components of translational machinery, ribosomal organisation, structure and functions of tRNA, rRNA and ribosomal proteins. Translational regulation: role of mRNA and its stability, antisense RNA, ribosomal frameshifts etc. Post translational modifications

DNA replication: General features; Replication in prokaryotes - *E. coli* and phages; Replication in eukaryotes.

### Unit 4
Transposition, Recombination & DNA repair. Transposable genetic elements in prokaryotes and eukaryotes. Transposition Mechanisms; Mechanism of genetic recombination. DNA repair

## Paper II - Bioprocess Engineering and Industrial Biotechnology

### Theory:

### Unit 1
Concepts of basic modes of fermentation - Batch, fed batch and continuous, conventional fermentation v/s biotransformation, solid substrate, surface and submerged fermentation, Fermentation economics, fermentation media, fermenter design-mechanically agitated, pneumatic and hydrodynamic fermenters; large scale animal and plant cell cultivation and air sterilisation

### Unit 2
Sterilisation of fermentation media; aeration and agitation in bioprocesses; scale-up of fermentation processes; process control in bioprocesses

### Unit 3
Microbial processes - production, optimization, screening, strain improvement, factors affecting, down stream processing and recovery of penicillin, streptomycin, citric acid, lysine, glutamic acid, ethanol, cyclodextrins and vitamins

### Unit 4
Enzyme Technology - production, recovery, stability and formulation of bacterial and fungal enzymes-amylase, protease, penicillin acylase, glucose isomerase; Immobilised enzymes and cell based biotransformations - steroids, antibiotics, alkaloids; enzyme/cell electrodes.

## Paper III - Cell Biology and Enzyme Kinetics

### Theory:

### Unit 1
Cell Biology. Subcellular compartments: Endo-plasmic reticulum, Golgi, lysosomes, microsomes etc. Mitochondria and chloroplasts; The nucleus; The cytoskeleton; Cell junctions and Cell adhesion; The extracellular matrix; Exo-and endocytosis

Tumour biology: Carcinogens, somatic and germ-line mutations, Tumour suppressor genes and their functions; Oncogenes and mechanisms of oncogene activation

### Unit 2
The eukaryotic cell cycle. Cyclins, cyclin-dependent kinases and their inhibitors; Cell cycle regulation in fission and budding yeasts; Complexity of metazoan cell cycles. Apoptosis.

Membranes: Membrane structure and properties; Biological roles of membranes; Membrane transport - passive transport, facilitated diffusion, coupled transport, membrane pumps. Membranes in signaling; Signal transduction pathways; Protein trafficking

## Unit 3

Advanced immunology: TCR and thymic selection; Immune tolerance, Autoimmunity and transplantation immunology; leukocyte trafficking; Accessory molecules; Inhibitory receptors. Recent developments in vaccines and monoclonal antibodies. Advances in Immunology

## Unit 4

Enzyme kinetics; Two-substrate kinetics and pre-steady state kinetics; Allosteric enzymes; Enzyme mechanisms; Enzyme inhibitors and active site determination

## Paper IV-Genetic Engineering

## Theory:

## Unit 1

Bacteriophage derived vectors in recombinant DNA: Lambda vectors, cosmids, phagemids/M13 vectors- Principle/strategies of construction and applications. Construction of transcriptional and translational fusions; Yeast vectors and cloning in yeast; Site directed mutagenesis

## Unit 2

Cloning in higher eukaryotes: Construction of genomic and cDNA libraries; Vectors used for genetic engineering of plants; Vectors derived from Agrobacterium T1 plasmid, CaMV, Animal viral vectors - SV-40, Vaccinia/Bacculovirus and retro-viral vectors

## Unit 3

Molecular markers in crop improvement.
Inherited human disorders. Techniques for studying differential gene expression; Yeast two hybrid system; phage display
Recombinant DNA products/applications: Insulin, hepatitis B antigen vaccine, growth hormones. Molecular farming, DNA finger printing, forensic applications. Transgenic plants and animals, knock out animals; Animal and plant cell culture and their applications; Stem cell biology.

## Unit 4

Gene transfer in bacteria: classical mechanisms.
Transformation in Bacteria - History, features, factors, physiology, mechanism
Bacterial conjugation: conjugable and other plasmids; features, physiology and genetics of F plasmid transfer; Hfr and F prime types, role of insertion elements, instabilities of F prime, use of Hfr and F prime in genetic mapping and cloning. Conjugation in non-enteric bacteria
Transduction: P1, P22 & Mu as generalised transducing phages; specialised transduction; lytic proficient and defective transducing phages; high frequency transduction; genetic mapping by generalised transducing phage

## Paper V - Genomics, Molecular Medicine and Advanced topics in Biotechnology

## Theory:

## Unit 1

Genomics and proteomics; Construction of physical maps; Map based cloning; Genome sequencing; functional genomics; Proteome analysis; Microarray technology

Non-coding RNAs and their roles in the cell; siRNA and its applications; Advanced topics

## Unit 2

Molecular Medicine: Structure and organisation of the human genome; chromosomal/molecular basis of human diseases with illustrative examples. Current methods of molecular diagnostics; Genomics and the identification of drug targets
Genetics of antibiotic synthesis and development of resistance; Genetically engineered antibiotics, biosynthesis and mode of action

## Unit 3

Bioinformatics: Introduction to databases; sequence analysis methods; Algorithms: Concept and their use in biology; Molecular modelling; Internet and its use in biology

Biosafety, Patents & IPR

## Unit 4

Evolution: Introduction to evolutionary theory: Processes and mechanisms of evolution; Non-Darwinian factors in evolution.

Prebiotic evolution; Molecular evolution - genes, non-coding DNA, mobile elements and genome structure

Protein folding; Protein stability

Biology of Infectious Diseases: Pathogenesis of prion and viral diseases. Bacterial and parasitic infections with reference to tropical infectious diseases such as TB, Malaria, Filariasis, arthropod vector borne diseases; functional genomics of pathogens