

M.Sc. Biotechnology Syllabus

(Effective from July 2013 academic year)

SEMESTER I

Paper I: Introductory Microbiology

(BT701) – credits

Basic microbiological methods

Pure culture techniques; Enrichment methods for specialised physiological groups; Sterilisation, disinfection and safety in the microbiological laboratory

Ultrastructure of a bacterial cell

Cell wall, flagella, cell membrane, capsule, pili, spores

Microbial systematics and Molecular Taxonomy

GC content analysis; Nucleic acid hybridisation, 16S rRNA phylogeny; Origin of life; Archaeobacteria

Microbial nutrition

Bioelements; Nutritional diversity with respect to carbon and energy sources; Chemotrophs (litho and organo); Phototrophs (litho and organo); Syntrophy

Paper II: Immunity and Infection-I

(BT702) – credits

Basic immunology

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 immunoglobulin genes

Host parasite interactions

Principles of virulence and pathogenicity; Innate host defences; Normal flora, Gnotobiology; Diagnostic principles; Principles of antimicrobial chemotherapy; Epidemiology, Study of representative human bacterial diseases caused by *Staphylococcus*, *Streptococcus*, *Neisseria*, *Shigella*, *Salmonella*, *Mycobacteri* and *Treponema*

Paper III: Biochemistry-I

(BT703) – credits

Chemistry of carbohydrates

Structure, properties, classification and functions of carbohydrates

Principles of bioenergetics

Laws of thermodynamics; The concept of free energy; High energy compounds; Biological oxidation-reduction

Lipids

Chemistry of fatty acids, Biosynthesis and degradation

Protein Structure and properties

Building blocks of proteins; Properties of amino acids; Composition of proteins; Primary, secondary, tertiary & quaternary structure of proteins; Properties of water; Physical interactions that determine properties of proteins; **UV/Visible absorption spectroscopy**

Water-soluble vitamins and coenzymes

Chemistry and biological roles in metabolism

Introduction to enzymes

Classification of enzymes; Enzyme properties; Enzyme assays and purification

The Urea cycle

Paper IV: Introductory genetics, Molecular biology & Genetic Engineering

(BT704) – credits

Basic genetics

Brief history; Mendel's laws; Linkage and recombination; Linkage mapping; Complementation analysis; Gene organisation; Mutations and their uses in genetic analysis

Regulation of transcription

The operon concept; Positive and negative regulation; Attenuation; Operon models: *lac*, *ara*, *trp* and *gal* operons

Introduction to genetic engineering

Enzymes used in recombinant DNA technology: Restriction enzymes, ligases, polymerases etc.; Plasmid and phage vectors

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

(BT705) – credits

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*

Mesoderm inducing factors in *Xenopus*; Cortical rotation, the Nieuwkoop Centre and Spemann's Organizer; "Dorsalising" and "ventralising" signals; Dorsal axis formation

Dictyostelium as a developmental system

Chemotaxis and signalling during aggregation; Pattern formation in aggregates; The *Dictyostelium* slug; Cell movements and chemical signals; Culmination

Structural determination and analysis of biomolecules

Intra- & intermolecular interactions; Structural determination and analysis of biomolecules; Absorption spectroscopy and other optical techniques like fluorescence; Circular dichroism

Environment & applications of microorganisms

Environmental pollution: Types, origin, monitoring in air, water and soil; Kinetics of biodegradation; Bioremediation approaches; Bioinsecticides; microbial ore leaching; Sewage and waste water management: Characterisation of waste water, conventional treatments, advances in aerobic and anaerobic treatment

SEMESTER II

Paper I: Microbial Diversity and Physiology

(BT801) – credits

Microscopy

Microscopy - general principles and optics of conventional, advanced and specialised microscopes

Study of microorganisms

General characteristics and salient features related to structure, function, physiology and significance of Cyanobacteria, Actinomycetes, Fungi, Yeast

Physiological Microbial diversity

Study of ecophysiological, biochemical and nutritional aspects of phylogenetically diverse representative groups of organisms:

Extremophiles - thermophiles, Psychrophiles, Halophiles; Methanogens; Archaeobacteria;

The Nitrogen cycle; Nitrogen fixing organisms

Microbial growth

Batch, fed-batch and continuous kinetics; Synchronous growth; Yield constants, Specific & volumetric rates; Methods of growth estimation; Growth phases; Shift-up, Shift-down, stringent response; Death of a bacterial cell

Paper II: Immunity and Infection-II

(BT802) – credits

Host responses to antigen

MHC structure and function; Antigen presentation; Cytokines; The complement system; Cell mediated immunity; Techniques in immunology; Inflammation and hyper-sensitivity; Immune response to infection; Vaccines and monoclonal antibodies; Immunodeficiency

Virology

Classification of viruses; Viral structure; Replication and expression of selected viruses; Viral pathogenesis

Pathogenesis

Fungal, Rickettsial, Mycoplasmal and Protozoal diseases; Principles of chemotherapy

Paper III: Biochemistry-II

(BT803) – credits

Metabolism of amino acids

Catabolism of amino acids, biosynthesis – aspartate family, aromatic family, branched chain amino acids, pyruvate family; Regulation of amino acid biosynthesis

Metabolism of carbohydrates

Metabolism of carbohydrates under aerobic, anaerobic and fermentative conditions by different modes; Anaplerotic pathway

Physical techniques and their applications in biology

Chromatographic techniques; Electrophoresis; Centrifugation and ultracentrifugation; Radioisotope techniques; X-ray crystallography

Nucleotide metabolism

Purine and pyrimidines

Paper IV: Introductory Genetics and Molecular Biology

(BT804) – credits

DNA Structure

DNA as the genetic material – history; The Watson-Crick model, structure and properties of B-form DNA; Alternative DNA structures; DNA denaturation and hybridisation; DNA supercoiling

The Genetic Code

General features; Elucidation of the genetic code; The genetic code table and organisation of the code; Deviations from the standard code

Drosophila as a genetic system

Advantages of *Drosophila* as a model system; Special genetic techniques in *Drosophila* – balancer chromosomes, genetic mosaics, enhancer trap and driver lines; The *Drosophila* P element and its uses as a vector and in transposon tagging

Introduction to yeast genetics

Yeast as a model system; Genetic analysis in yeast

Prokaryotic transcription

General features; Structure & function of RNA polymerase, Promoter properties; Transcription pathway

Introduction to Bacteriophages & phage genetics

Physiology, replication and regulation of single & double stranded phages; Lysogeny and lytic cycle - λ as a model system; General characteristics and physiology of single- and double-stranded phages; The T series phages

Paper V: Developmental Biology, Biophysics and Biostatistics

(BT805) – credits

Drosophila development

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

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 and memory

Biostatistics

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

Structural determination and analysis of biomolecules

Study of biological structure and function using absorption spectroscopy; Infrared spectroscopy and Raman spectroscopy; Nuclear Magnetic Resonance Spectroscopy; ESR; Size and shape of macromolecules; light scattering; Analytical ultracentrifugation and other hydrodynamic techniques

Environmental Biotechnology

Biofertilisers

SEMESTER III

Paper I: Molecular Biology-I

(BT 901) - credits

Genome organisation in eukaryotes

The nucleus and chromatin; The nucleosome; Chromatin structure, modifications and regulation; Position effect variegation; Polycomb group and Trithorax group complexes and cell memory; Insulators and boundary elements; DNA methylation and imprinting

Eukaryotic transcription

General features; Structure and function of eukaryotic RNA polymerases; Transcriptional regulation in eukaryotes; DNA binding proteins

Mutations

Chemical and physical bases of mutations and mutagenesis; Types of mutations; Mutations and disease; Site directed mutagenesis

Transposable elements in bacteria

Classification; IS elements; Composite transposons and the TnA family; Mechanisms of transposition

Paper II: Bioprocess Engineering and Industrial Biotechnology

(BT902) – credits

Fermentation

Principles of fermentation; Bioprocess optimisation; Fermentation media; Bioreactor design and its modifications; Large-scale plant and animal cell culture

Microbial processes

Production, optimisation, screening and strain improvement; Downstream processing

Industrial fermentations

Amino acid biosynthesis and regulation; Industrial production of glutamate; Fermentation kinetics; Production of penicillin, streptomycin, citric acid, ethanol etc.; Recombinant DNA products

Paper III: Cell Biology and Enzymology-I

(BT903) – credits

The cell cycle

The eukaryotic cell cycle; Mitosis; Cyclins, CDKs and their inhibitors; Cell cycle regulation

Enzyme kinetics

Single substrate, two-substrate and pre-steady state kinetics; Kinetics of enzyme inhibition

Oxidative phosphorylation/photosynthesis

Electron transport systems; Theories of oxidative phosphorylation; Structure and function of ATPases

Subcellular compartments and structures

Mitochondria, chloroplasts and lysosomes; The cytoskeleton; Motor proteins; Protein translocation; Protein sorting and vesicular trafficking

Cellular immunology

TCR; Thymic selection; T cell activation and differentiation; γ and δ T cells

Paper IV: Genetic Engineering in Microbes

(BT904) – credits

Bacterial genetics

Transformation, conjugation, transduction

Vectors

Plasmid vectors; Bacteriophage-derived vectors in recombinant DNA work; Lambda vectors, cosmids, phagemids/M13 vectors; Principles/strategies of vector construction and applications; Construction of transcriptional and translational fusions

Genomics and proteomics

Site-directed mutagenesis

Paper V: Advanced topics

(BT 905) – credits

Antibiotics

Synthesis, regulation and mode of action; Antibiotic resistance

Protein folding

Protein folding and stability

Evolution

History of evolutionary theory; Evidences for evolution; Processes and mechanisms of evolution; Non-Darwinian factors; Speciation; Evolvability; Molecular and genomic evolution

SEMESTER IV

Paper I: Molecular Biology-II

(BT 001) – credits

RNA processing – Post-transcriptional modifications; mRNA, ribosomal RNA and tRNA processing; mRNA and organellar RNA splicing; Role of maturases; RNA editing; RNA as catalyst

Nuclear organisation

Nuclear architecture and compartmentation; The nuclear matrix; Chromosome territories; Epigenetics

Replication

DNA replication in prokaryotes: *E. coli* and phages; replication in animal viruses and eukaryotes

Repair

DNA repair

Recombination

Recombination in prokaryotes and yeast

Translation

Translation in prokaryotes and eukaryotes; The translational machinery; ribosomal organisation; structure and functions of tRNA, rRNA and ribosomal proteins; Translational regulation

Paper II: Industrial Biotechnology

(BT 002) – credits

Fermentation

Sterilisation of air and fermentation media; Aeration and agitation in bioprocesses; Scale-up of fermentation processes; Instrumentation and process control in bioprocesses

Industrial production

Industrial enzyme technology – production, recovery and formulation of bacterial and fungal enzymes like amylases, proteases, penicillin acylase and glucose isomerase

Immobilised enzymes and cell-based bio-transformations of steroids; Biosensors

Paper III: Cell Biology and

Enzymology-II

(BT 003) – credits

Membrane biology

Membrane structure and properties
Membrane transport; Membranes in signalling

Cell communication

Intracellular signalling pathways: MAP kinase pathways; G proteins; Phosphoinositides etc.; Cell junctions and cell adhesion; The extracellular matrix

Cellular immunology

Leukocyte trafficking; Immune tolerance and autoimmunity; chemokines and receptors

Enzymology

Mechanisms of enzyme action; Active site determination; Allostery

Paper IV: Advanced topics

(BT 004) – credits

Yeasts in DNA manipulation

Yeast vectors and cloning in yeast; the yeast two-hybrid system

Prions in mammals and yeast

Bioinformatics

Basic concepts; Internet resources and databases; bioinformatics methods for analysis of sequence and structural data

Protein folding

Advanced topics in protein folding; protein folding in biotechnology

Paper V: Genetic Engineering in Eukaryotes

(BT 005) – credits

Animal cell biotechnology

Animal and animal virus-based vectors; Cloning in animal cells

DNA libraries and cloning

Construction and screening of genomic and cDNA libraries

Map-based cloning and marker-assisted selection; DNA fingerprinting

Transgenics

Transgenic plants and animals; molecular markers in crop improvement

Techniques for studying differential gene expression

SABRE etc

Intellectual property rights

IPR; Patents