

M.Sc Biotechnology Syllabus

SEMESTER I

Paper I : Introductory Microbiology

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.

Basic microbiological methods:

Pure culture techniques, Enrichment methods for specialised physiological groups, Sterilization, Disinfection, Safety in the microbiological laboratory

Microbial nutrition :

Bioelements, Nutritional diversity with respect to carbon and energy sources, Chemo (litho and organo) trophs, Photo(litho and organo) trophs, Syntrophy.

Microbial growth :

Batch, Fed-batch, 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 (I)

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 interaction :

Principles of virulence and pathogenicity, Innate host defences, Normal flora, Gnotobiology, Host-parasite interaction, Epidemiology, Study of representative human bacterial diseases.

Paper III : Biochemistry (I)

Metabolism of carbohydrates :

Chemistry of carbohydrates, Metabolism of carbohydrates under aerobic, Anaerobic and fermentative conditions by different modes, Anaplerotic pathway, Principles of bioenergetics.

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. Study of biological structure & function using absorption spectroscopy

Nucleotide metabolism :

Purine and pyrimidines.

Paper IV : Introductory genetics, Molecular biology & Genetic Engineering

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

Regulation of transcription:

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 (I)

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.

Structural determination and analysis of biomolecule :

Intra & intermolecular interactions, Structural determination and analysis of biomolecule, Absorption spectroscopy and other optical techniques like fluorescence, Circular dichroism.

Applications of micro-organisms :

Bioinsecticides, Biofertilisers and in microbial ore leaching.

SEMESTER II

Paper I : Microbial Diversity and Physiology

Ultrastructure of a bacterial cell :

Microscopy - general principles and optics of conventional, Advanced and specialized microscopes

Chemistry, Structural and functional features :

Cell wall, flagella, Cell membrane, Capsule, Pili, Spore.

Microbial systematics and Molecular Taxonomy :

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

Physiological Microbial diversity :

Study of ecophysiological, Biochemical and nutritional aspects of phylogenetically diverse representative groups of organisms, Extremophiles - thermophiles, Psychrophiles, Halophiles, Methanogens, Archaeobacteria, Nitrogen fixing organisms.

Paper II : Immunity and Infection (II)

Host response to antigen :

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

Virology :

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

Study on pathogenesis :

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

Paper III : Biochemistry (II)

Metabolism of amino acids :

Catabolism of amino acids, biosynthesis – aspartate family, Aromatic family, Branched chain amino acids, Pyruvate family, Regulation of amino acid Biosynthesis, Urea cycle.

Lipids :

Chemistry of fatty acids, Biosynthesis and Degradation

Enzymes :

Classification, Properties, Enzyme assays and Purification.

Study of vitamins and coenzymes :

Chemistry and Biological role in metabolism.

Physical techniques and their applications in biology :

Chromatographic techniques, Electrophoresis, Centrifugation and Ultracentrifugation, Radioisotope techniques, X-ray crystallography.

Paper IV : Introductory genetics and Molecular biology

DNA Structure :

DNA as the genetic material – history of ideas and experiments, The Watson-Crick model. Structure and

properties of B-form DNA. Alternative DNA structures. DNA denaturation and hybridization, supercoiling.

Genetic Code :

General features, Elucidation of the genetic code, The genetic code table and organization 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.

Prokaryotic transcription :

General features, Structure & function of RNA polymerase, Promoter parameters and specifications, 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

Paper V : Developmental Biology, Biophysics and Environmental Biotechnology (II)

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

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

Structural determination and analysis of biomolecules :

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 :

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.

SEMESTER III

Paper I: Molecular Biology I

Genome organisation in eukaryotes;

Chromatin structure, modifications and regulation; DNA methylation and imprinting

Eukaryotic transcription – general features;

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

Translation in prokaryotes and eukaryotes; The translational machinery, ribosomal organisation, structure and functions of

tRNA, rRNA and ribosomal proteins; Translational regulation

Transposable elements in bacteria

Paper II: Bioprocess Engineering and Industrial Biotechnology

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; Biotransformation;

Fermentation kinetics; Production of penicillin, streptomycin, citric acid and ethanol; Downstream processing

Paper III: Cell Biology and Enzyme Kinetics I

The eukaryotic cell cycle; Mitosis; Cyclins, CDKs and their inhibitors; Cell cycle regulation in G2, G1 and S phases

Membrane biology: membrane structure and properties

Subcellular compartments; The cytoskeleton; Motor proteins;

Protein sorting and vesicular trafficking; TCR; Thymic selection;

Enzyme kinetics – Single substrate, two-substrate and pre-steady state kinetics;

Kinetics of enzyme inhibition

Paper IV: Genetic Engineering in microbes

Bacterial genetics – transformation, conjugation and transduction

Plasmid vectors; Bacteriophage-derived vectors in recombinant DNA work; Lambda vectors, cosmids, phagemids/M13 vectors; Yeast vectors and cloning in yeast

Principles/strategies of vector construction and applications; Construction of transcriptional and translational fusions

Construction and screening of genomic and cDNA libraries

Yeast two-hybrid system; Transgenic plants and animals; Molecular markers in crop improvement

Paper V: Advanced topics

Genomics

Antibiotics – synthesis, regulation, mode of action; Antibiotic resistance

Protein folding and stability

Evolution – Introduction to evolutionary theory; Processes and mechanisms of evolution; Non-Darwinian factors in evolution; Speciation; Evolvability; Molecular and genomic evolution

SEMESTER IV

Paper I: Molecular Biology II

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

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

Mutations and mutagenesis; DNA repair
Recombination in prokaryotes and yeast

Paper II: Industrial Biotechnology

Sterilisation of air and fermentation media; Aeration and agitation in bioprocesses

Scale-up of fermentation processes;
Instrumentation and process control in bioprocesses

Amino acid biosynthesis and regulation; Industrial enzyme technology – production, recovery and formulation of bacterial and fungal enzymes like amylases, proteases, penicillin acylase and glucose isomerase; Industrial production of glutamate, 2,3 butanol, Vitamin B₁₂ and cyclodextrins

Immobilised enzymes and cell-based biotransformations of steroids, antibiotics and alkaloids; Biosensors

Paper III: Topics in Cell Biology and Enzymology

Biological roles of membranes; Membrane transport; Membranes in signalling; Signal transduction pathways

Organelle genetics

Cell junctions; Leukocyte trafficking
Mechanisms of enzyme action; Active site determination; Allostery

Paper IV: Genetic Engineering in eukaryotes

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

Site-directed mutagenesis

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

Techniques for studying differential gene expression

Paper V: Advanced topics

Proteomics

Bioinformatics; Intellectual property rights
Protein folding and stability