

### Section 1: Engineering Mathematics

**Linear Algebra:** Matrices and determinants; Systems of linear equations; Eigen values and Eigen vectors.

**Calculus:** Limits, continuity and differentiability; Partial derivatives, maxima and minima; Sequences and series; Test for convergence.

**Differential Equations:** Linear and nonlinear first order ODEs, higher order ODEs with constant coefficients; Cauchy's and Euler's equations; Laplace transforms.

**Probability and Statistics:** Mean, median, mode and standard deviation; Random variables; Poisson, normal and binomial distributions; Correlation and regression analysis.

**Numerical Methods:** Solution of linear and nonlinear algebraic equations; Integration by trapezoidal and Simpson's rule; Single step method for differential equations.

### Section 2: General Biology

**Biochemistry:** Biomolecules - structure and function; Biological membranes - structure, membrane channels and pumps, molecular motors, action potential and transport processes; Basic concepts and regulation of metabolism of carbohydrates, lipids, amino acids and nucleic acids; Photosynthesis, respiration and electron transport chain. Enzymes - Classification, catalytic and regulatory strategies; Enzyme kinetics - Michaelis-Menten equation; Enzyme inhibition - competitive, non-competitive and uncompetitive inhibition.

**Microbiology:** Bacterial classification and diversity; Microbial Ecology - microbes in marine, freshwater and terrestrial ecosystems; Microbial interactions; Viruses - structure and classification; Methods in microbiology; Microbial growth and nutrition; Nitrogen fixation; Microbial diseases and host-pathogen interactions; Antibiotics and antimicrobial resistance.

**Immunology:** Innate and adaptive immunity, humoral and cell mediated immunity; Antibody structure and function; Molecular basis of antibody diversity; T cell and B cell development; Antigen-antibody reaction; Complement; Primary and secondary lymphoid organs; Major histocompatibility complex (MHC); Antigen processing and presentation; Polyclonal and monoclonal antibody; Regulation of immune response; Immune tolerance; Hypersensitivity; Autoimmunity; Graft versus host reaction; Immunization and vaccines.

### Section 3: Genetics, Cellular and Molecular Biology

**Genetics and Evolutionary Biology:** Mendelian inheritance; Gene interaction; Complementation; Linkage, recombination and chromosome mapping; Extra chromosomal inheritance; Microbial genetics - transformation, transduction and conjugation; Horizontal gene transfer and transposable elements; Chromosomal variation; Genetic disorders; Population genetics; Epigenetics; Selection and inheritance; Adaptive and neutral evolution; Genetic drift; Species and speciation.

**Cell Biology:** Prokaryotic and eukaryotic cell structure; Cell cycle and cell growth control; Cell-cell communication; Cell signaling and signal transduction; Post-translational modifications; Protein trafficking; Cell death and autophagy; Extra-cellular matrix.

**Molecular Biology:** Molecular structure of genes and chromosomes; Mutations and mutagenesis; Regulation of gene expression; Nucleic acid - replication, transcription, splicing, translation and their regulatory mechanisms; Non-coding and micro RNA; RNA interference; DNA damage and repair.

## **Section 4: Fundamentals of Biological Engineering**

**Engineering principles applied to biological systems:** Material and energy balances for reactive and non-reactive systems; Recycle, bypass and purge processes; Stoichiometry of growth and product formation; Degree of reduction, electron balance, theoretical oxygen demand.

**Classical thermodynamics and Bioenergetics:** Laws of thermodynamics; Solution thermodynamics; Phase equilibria, reaction equilibria; Ligand binding; Membrane potential; Energetics of metabolic pathways, oxidation and reduction reactions.

**Transport Processes:** Newtonian and non-Newtonian fluids, fluid flow - laminar and turbulent; Mixing in bioreactors, mixing time; Molecular diffusion and film theory; Oxygen transfer and uptake in bioreactor,  $k_L a$  and its measurement; Conductive and convective heat transfer, LMTD, overall heat transfer coefficient; Heat exchangers.

## **Section 5: Bioprocess Engineering and Process Biotechnology**

**Bioreaction engineering:** Rate law, zero and first order kinetics; Ideal reactors - batch, mixed flow and plug flow; Enzyme immobilization, diffusion effects - Thiele modulus, effectiveness factor, Damkohler number; Kinetics of cell growth, substrate utilization and product formation; Structured and unstructured models; Batch, fed-batch and continuous processes; Microbial and enzyme reactors; Optimization and scale up.

**Upstream and Downstream Processing:** Media formulation and optimization; Sterilization of air and media; Filtration - membrane filtration, ultrafiltration; Centrifugation - high speed and ultra; Cell disruption; Principles of chromatography - ion exchange, gel filtration, hydrophobic interaction, affinity, GC, HPLC and FPLC; Extraction, adsorption and drying.

**Instrumentation and Process Control:** Pressure, temperature and flow measurement devices; Valves; First order and second order systems; Feedback and feed forward control; Types of controllers – proportional, derivative and integral control, tuning of controllers.

## **Section 6: Plant, Animal and Microbial Biotechnology**

**Plants:** Totipotency; Regeneration of plants; Plant growth regulators and elicitors; Tissue culture and cell suspension culture system - methodology, kinetics of growth and nutrient optimization; Production of secondary metabolites; Hairy root culture; Plant products of industrial importance; Artificial seeds; Somaclonal variation; Protoplast, protoplast fusion - somatic hybrid and cybrid;

Transgenic plants - direct and indirect methods of gene transfer techniques; Selection marker and reporter gene; Plastid transformation.

**Animals:** Culture media composition and growth conditions; Animal cell and tissue preservation; Anchorage and non-anchorage dependent cell culture; Kinetics of cell growth; Micro & macro-carrier culture; Hybridoma technology; Stem cell technology; Animal cloning; Transgenic animals; Knock-out and knock-in animals.

**Microbes:** Production of biomass and primary/secondary metabolites - Biofuels, bioplastics, industrial enzymes, antibiotics; Large scale production and purification of recombinant proteins and metabolites; Clinical-, food- and industrial- microbiology; Screening strategies for new products.

## **Section 7: Recombinant DNA technology and Other Tools in Biotechnology**

**Recombinant DNA technology:** Restriction and modification enzymes; Vectors - plasmids, bacteriophage and other viral vectors, cosmids, Ti plasmid, bacterial and yeast artificial chromosomes; Expression vectors; cDNA and genomic DNA library; Gene isolation and cloning, strategies for production of recombinant proteins; Transposons and gene targeting;

**Molecular tools:** Polymerase chain reaction; DNA/RNA labelling and sequencing; Southern and northern blotting; In-situ hybridization; DNA fingerprinting, RAPD, RFLP; Site-directed mutagenesis; Gene transfer technologies; CRISPR-Cas; Biosensing and biosensors.

**Analytical tools:** Principles of microscopy - light, electron, fluorescent and confocal; Principles of spectroscopy - UV, visible, CD, IR, fluorescence, FT-IR, MS, NMR; Electrophoresis; Micro-arrays; Enzymatic assays; Immunoassays - ELISA, RIA, immunohistochemistry; immunoblotting; Flow cytometry; Whole genome and ChIP sequencing.

**Computational tools:** Bioinformatics resources and search tools; Sequence and structure databases; Sequence analysis - sequence file formats, scoring matrices, alignment, phylogeny; Genomics, proteomics, metabolomics; Gene prediction; Functional annotation; Secondary structure and 3D structure prediction; Knowledge discovery in biochemical databases; Metagenomics; Metabolic engineering and systems biology.