BT Biotechnology

Section 1: Engineering Mathematics

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

Calculus: Multivariable calculus (limits, continuity, and differentiability); Partial derivatives, maxima and minima; Sequences and series; Test for convergence. Multivariable calculus: Gradient, divergence, and curl (for applications in fluid mechanics, transport processes, etc.).

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; Bayesian Statistics.

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; Metabolism: Regulation of metabolism of carbohydrates, lipids, amino acids, and nucleic acids; Detailed pathways like glycolysis, citric acid cycle, and fatty acid oxidation; 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: History of Microbiology, Bacterial classification and diversity; Bacterial cell wall composition, Gram positive and Gram-negative bacteria, Archea, Methods in microbiology; Microbial growth and nutrition; Operon- Lac, Trp and Ara operon, Nitrogen fixation; Microbial diseases and host-pathogen interactions; Antibiotics and antimicrobial resistance, Two-component system (TCS), bacterial communication, Viruses - structure and classification.

Immunology: Primary and Secondary lymphoid organs; Innate immunity and Inflammation; Cytokines and Chemokines; Complement system; Effector responses: Cellular and Humoral Immunity; Molecular basis of Antibody diversity and function; Polyclonal and Monoclonal antibodies; T-cell and B-cell development; Memory responses; Major Histocompatibility complex (MHC); Antigen processing and presentation; Regulation of immune responses; Immune tolerance; Hypersensitivity; Autoimmunity and Immunodeficiency; Graft vs Host disease; 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; Bacterial gene mapping; Horizontal gene transfer and transposable elements; Chromosomal variation; Sex Determination; Genetic disorders; Population genetics; Epigenetics; Selection and inheritance; Adaptive and neutral evolution; Genetic drift; Species and speciation.

Cell Biology: Eukaryotic cell structure; Cell cycle and cell growth control; Cell-cell communication; Cell signalling and signal transduction; Non-cell autonomous cell signalling; Post-translational modifications; Protein trafficking; Cell death and autophagy; Extra-cellular matrix.

Section 4:	Fundamentals of Biological Engineering

Bioreaction Engineering: Rate law, zero and first order kinetics; (More advanced kinetic models, including **Michaelis-Menten kinetics** for enzyme reactions. **Inhibition kinetics**: Competitive, non-competitive, and uncompetitive inhibition in enzyme catalysis); Ideal reactors - batch, mixed flow and plug flow; Enzyme immobilization, diffusion effects - Thiele modulus, effectiveness factor, Damkoehler 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 (Design and operation of microbial reactors (e.g., fermentation reactors) and enzyme reactors (e.g., immobilized enzyme systems); Case studies on the use of microbial reactors in large-scale production (e.g., antibiotics, biofuels).

Upstream and Downstream Processing: Media formulation and optimization; Sterilization of air and media; Filtration - membrane filtration, ultra filtration; 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; 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 5:	Plant, Animal and Microbial Biotechnology

Plants: Totipotency; Cell fate transition, direct and indirect organogenesis, 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 6:	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; Gene isolation and cloning, strategies for production of recombinant proteins; Transposons and gene targeting, Recombination-based gene cloning.

Molecular tools: Polymerase chain reaction; DNA/RNA labelling and Sangers and next generation sequencing; Southern and northern blotting; In-situ hybridization; DNA fingerprinting, RAPD, RFLP; Site-directed mutagenesis; CRISPR-Cas; Biosensing and biosensors; DNA-protein and protein-protein interaction tools; Genomics and proteomics-based approaches.

Analytical tools: Principles of microscopy - light, electron, fluorescence and confocal; Principles ofspectroscopy-UV, visible, fluorescence, CD, IR, 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.