Syllabus of Biotechnology

Unit-1

- Structure of Prokaryotic and Eukaryotic cells.
- Structure and functions of Cellular organelles viz. plasma membrane, mitochondria, chloroplast, nucleus, golgi bodies, endoplasmic reticulum.
- Active and passive transport of nutrients, ions and macromolecules.
- Cell cycle – Molecular events and model systems.
- Cellular responses to environmental signals in plants and animals – Mechanisms of signal transduction, Biology of cancer.
- Metabolite pathways viz. EMP pathway, pentose phosphate pathway, kreb’s cycle, glucuronate-xylulose pathway and their regulations.
- Development in Drosophila and Arabidopsis, Spatial and temporal regulation of gene Expression.
- Introduction to the Life Cycle and Molecular Biology of some important pathogens of AIDS, Malaria, Hepatitis, Tuberculosis.

Unit-2

- Amino acids and peptides – classification, chemical reactions and physical properties.
- Sugars – classification and reactions.
- Polysaccharides viz. starch, amylose, amylopectin, glycogen, cellulose, chitin, pectin, agar.
- Lipids – Structure and functions of fats, waxes, phospholipids, sphingolipids.
- Proteins – Classification and separation, Purification and criteria of homogeneity, End group analysis.
- Basic energy concepts – Enthalpy, Entropy, Free energy changes.
- Discovery, classifications and nomenclature of enzymes.
- Allosterism, Structure and activity of the enzymes, Mechanism of action of chymotrypsin, Glyceraldehyde-3-phosphate dehydrogenase, Lysozyme, Carboxy peptidase, Ribonuclease, Aldolase, etc.
- Isolation and purification of enzymes.
- Isozymes, Multienzyme complexes, Multifunctional enzymes.
- Synzymes, Abzymes, Ribozyme.

Unit-3

- Prokaryotic and eukaryotic DNA replication, Enzymes and accessory proteins involved in DNA replication, DNA repair.
Transcription in prokaryotes as well as eukaryotes- RNA polymerases, General and specific transcription factors, Regulatory elements, 5'-capping, Polyadenylation.

Protein Biosynthesis in prokaryotes as well as eukaryotes, Co-and post-translational modifications, Intracellular protein trafficking.

Gene editing tools including CRISPR, ZFNs and TALENs.

Viral and cellular oncogenes; Tumour suppressor genes from humans; Structure, function and mechanism of action of pRB and p53 tumour suppressor proteins.

Holiday junction, Gene targeting, Gene disruption, FLP/FRT and Cre/Lox recombination, RecA and other recombinases.

RFLP, RAPD and AFLP analysis, Molecular markers linked to disease resistance genes.

Epigenetic regulation of DNA and its role in gene expression levels, Therapeutic approaches based on modulation of epigenetic changes.

Unit-4

Alternative strategies of gene cloning.

Sequencing of proteins and nucleic acids.

Microarrays, Serial analysis of gene expression (SAGE).

Molecule marker – aided Breeding: RFLP maps, Linkage analysis, RAPD markers, Microsatellites, SCAR (sequence characterized amplified regions), SSCP (single strand conformational polymorphism), AFLP, QTL, Map based cloning, Molecular marker assisted selection. Molecular tools and their applications: Restriction endonucleases, Modification enzymes, DNA and RNA markers, cDNA Synthesis and cloning: mRNA enrichment, Reverse transcription, DNA primers, Linkers, adaptors and their chemical synthesis, Library construction and screening.

Site-directed mutagenesis and protein engineering. Expression strategies for heterologous genes: Vector engineering and codon optimization, Host engineering, In vitro transcription and translation, Expression in bacteria, Expression in yeast, Expression in insects and insect cells, Expression in mammalian cells, Expression in plants.

Processing of recombinant proteins: Purification and refolding, Characterization of recombinant proteins, Stabilization of proteins, Gene therapy: Vector engineering, Gene replacement/augmentation, Gene correction, Gene editing, Gene regulation and Silencing.

Unit-5

Physical techniques in protein, nucleic acids and polysaccharide structural analysis (UV, IR NMR, LASER Raman Spectroscopy, Mass Spectroscopy, Florescence Spectroscopy). Differential colorimetry, X-ray
crystallography, Ultra centrifugation, Confocal and electron microscopy techniques, Autoradiography.

- Methods in biophysical analysis: CD, ORD, Raman spectroscopy, Various types of chromatography including TLC, Column chromatography, Adsorption chromatography, Ion-exchange chromatography, Gel filtration chromatography, Affinity chromatography, Reverse phase chromatography, HPLC.

- Microscopy: Phase contrast, Fluorescence microscopy, Electron microscopy and Scanning tunnelling microscopy.

- Radio isotope techniques: Detection and measurement of radio activity, Units of radioactivity, Geiger Muller counter, Scintillation counter, Autoradiography and Radioimmunoassay, Applications of isotopes in biological studies.

Unit-6

- Initiation and maintenance of callus and suspension culture, Single cell clones.


- Plant transformation technology: Basis of tumour formation, Hairy root, Features of TI and RI plasmids, Mechanisms of DNA transfer, Role of virulence genes, Use of TI and RI as vectors, Binary vectors, Use of 35S and other promoters, Genetic markers, Use of reporter genes.

Unit-7

- Innate and acquired immunity, Clonal nature of immune response antigens and super antigens antibody structure and function, Antigen-antibody interactions. Major histocompatibility complex, T- lymphocytes, Macrophages, Dendritic cells, Natural killer and Lymphokine activated killer cells, Eosinophils, Neutrophils and Mast-cells.

- Regulation of immune response, Antigen processing and presentation, Generation of humoral and cell mediated immune responses, Activation of B- and T- lymphocytes hypersensitivity, Autoimmunity, Transplantation immunity to infectious agents.

- Applications of animal cell culture, Stem cell cultures, Isolation, Selection markers cryopreservation, Banking and stem cell based therapies. Cell culture based vaccines.
Unit-8

- Isolation, preservation and maintenance of industrial microorganisms.
- Types of fermentation processes: Analysis of batch, fed-batch and continuous bioreactors; Analysis of mixed microbial populations.
- Microbiology of waste water treatments, Aerobic process: Activated sludge, Oxidation ditches, Trickling filter, Towers, Rotating discs, Rotating drums, Oxidation ponds.
- Microbiology of degradation of Xenobiotics in environment, Ecological considerations, Oil pollution, Surfactants, Biopesticides.
- Bioremediation of contaminated soils and waste land.
- Biopesticides in integrated pest management. Global environment problems: Ozone depletion, UV-B, Greenhouse effect and acid rain, their impact and biotechnological approaches for management.
- Downstream processing: introduction.
- Removal of microbial cells and solid matter, Foam separation, Precipitation, Filtration, Centrifugation, Cell disruptions, Liquid-liquid extraction, Chromatography, Membrane process, Drying and Crystallization.
- Industrial production of chemicals: Alcohol (ethanol), Acids (citric, acetic and gluconic acids), Solvents (glycerol, acetone, butanol), Antibiotics (penicillin, streptomycin).

Unit-9

- Secondary metabolites - Various pathways for secondary metabolites viz. alkaloids, phenolics, lignins, terpenoids flavonoids, porphyrins, importance of secondary metabolites in medicine and agriculture.
- Rare metabolic conversions, Mass balances, Rates and experiments, Models for growth and Product formation.
- Bacterial transcriptional regulation of metabolism.
- Modelling tools for metabolic engineering: Metabolic flux analysis, Control analysis, Multi scale modelling of metabolic regulation.
- Anaerobic processes: Anaerobic digestion, Anaerobic filters.
- Upflow anaerobic sludge blanket reactors.

Unit-10

- Computer aided drug designing, Computational techniques in structural analysis: Nanoparticles.
- Measures of central tendency and dispersion: mean, median, mode, range, standard deviation, variance, idea of two types of errors and level of significance, tests of significance (F & t-test); Chi-square test, Standard deviation; Correlation coefficient.
- Probability, Concept of probability theory, Events, Trials, Mutually exclusive events, Favourable events, Exhaustive events, Bayesian theorem of probability, Addition theorem, Multiplication theorem, Binomial distribution, Normal distribution.
- Design of experiments, ANOVA (one-way and two-way), F-test.
- Simple regression and correlation.
- Ethics: Basic aspects of research ethics.
- Biosafety in the laboratory institution: Laboratory associated with infections and other hazards, Assessment of biological hazards and levels of biosafety, Prudent biosafety practices in the laboratory/institution.
- Biosafety regulations in the handling of recombinant DNA processes and product in institutions and industries.
- Basic requirements of patentability: Patentability subject matter, Novelty and the public domain, Non-obviousness.
- Special issues in biotechnology patents: Disclosure requirements, Collaborative research, Competitive research.