10 MOLECULAR BIOLOGY & BIOTECHNOLOGY

Unit 1: Cell Structure and Function

Prokaryotic and eukaryotic cell architecture, Cell wall, plasma membrane, Structure and function of cell organelles: Nucleus, vacuoles, mitochondria, plastids, Golgi apparatus, ER, lysosomes, peroxisomes, glyoxisomes. Cell cycle-Regulation of cell cycle. Cell division, growth and differentiation. Protein secretion and targeting. Transport across cell membrane, Cell signaling, Developmental biology of plants, programmed cell death (apoptosis), Cell renewal and cancer, stem cell applications.

Unit 2: Biomolecules and Metabolism

Structure and function of carbohydrates, lipids, proteins and nucleic acids, Synthesis of carbohydrate, glycolysis, HMP, Citric acid cycle and metabolic regulation, Oxidative phosphorylation and substrate level phosphorylation, Vitamins, plant and animal hormones. Functional molecules, antioxidants, nutrient precursor, HSPs, anti-viral compounds.

Unit 3: Enzymology

Enzymes, structure conformation, classification, assay, isolation, purification and characterization, catalytic specificity, mechanism of action, active site, regulation of enzyme activity, multienzyme complexes, immobilized enzymes and protein engineering, immobilized enzymes and their application.

Unit 4: Molecular Genetics

Concept of gene, Prokaryotes as genetic system, Prokaryotic and eukaryotic chromosomes, methods of gene isolation and identification, Split genes, overlapping genes and pseudo genes, Organization of prokaryotic and eukaryotic genes and genomes including operon, exon, intron, enhancer promoter sequences and other regulatory elements. Mutation – spontaneous, induced and site-directed, recombination in bacteria, fungi and viruses, transformation, transduction, conjugation, transposable elements and transposition.

Unit 5: Gene Expression

Expression of genetic information, operon concept, Transcription – mechanism of transcription in prokaryotes and eukaryotes, transcription unit, regulatory sequences and enhancers, activators, repressors, co-activators, Co-repressors in prokaryotes and eukaryotes, inducible genes and promoters, Transcription factors post transcriptional modification and protein transport, DNA-protein interaction, Genetic code. Mechanism of translation and its control, post translational modifications. Epigenetic control of gene expression; Regulatory RNA in gene regulation - Small RNAs, RNA interference and its applications.

Unit 6: Molecular Biology Techniques

Isolation and purification of nucleic acids. Nucleic acids hybridization: Southern, northern and western blotting hybridization. Immune response monoclonal and polyclonal antibodies and ELISA, DNA sequencing. Construction and screening of genomic and C-DNA libraries. Gel electrophoretic techniques. Spectroscopy,Polymerase chain reaction, real time PCR, RT-PCR, ultracentrifugation, chromatography, FISH, RIA, etc. Next generation genome sequencing techniques, basic bioinformatics, microarray, etc. Proteomics, 2D and protein sequencing, metabolomics.

Unit 7: Gene Cloning

DNA manipulative and modifying enzymes-restriction enzymes and their uses. Salient features and uses of most commonly used vectors i.e. plasmids, bacteriophages, phagemids, cosmids, BACs, PACs and YACs, binary vectors, expression vectors. Gateway cloning vectors. Gene cloning and sub-cloning strategies, chromosome walking, genetic transformation, Basis of animal cloning. Gene pyramiding and gene fusion, ribozyme technology. Biological risk assessment and IPR.

Unit 8: Molecular Biology

Genome complexity-C value and C-value paradox; DNA re-association kinetics. Analysis of repetitive sequences. Molecular events in DNA replication, transcription and translation. RNA processing and Post transcriptional modifications. Ribosome structure and function. Protein biosynthesis in prokaryotes and eukaryotes. Post-translational modification. Gene regulation, DNA damage-types and repair mechanisms. Bioprospecting. Non coding RNA.

Unit 9: Plant Molecular Biology

Photoregulation and phytochrome regulation of nuclear and chloroplastic gene expression. Molecular mechanism of nitrogen fixation. Advances in conversion of C3 to C4 pathway. Molecular biology of various stresses, viz. abiotic stresses like drought, salt, heavy metals and temperature; and biotic stresses like bacterial, fungal and viral diseases. Signal transduction and its molecular basis, molecular mechanism of plant hormone action, Hormone regulatory pathways, mitochondrial control of fertility, structure, organization and regulation of nuclear gene concerning storage proteins and starch synthesis. Crop genome sequencing projects.

Unit 10: Tissue Culture

Basic techniques in cell culture and somatic cell genetics. Clonal propagation. Concept of cellular totipotency. Androgenesis and gynogenesis, somaclonal and gametoclonal variations. Hybrid embryo culture and embryo rescue, somatic hybridization and cybridization. Application of tissue culture in crop improvement. Secondary metabolite production. In vitro mutagenesis, cryopreservation and plant tissue culture repository. Synthetic seeds, Virus indexing.

Unit 11: Plant Genetic Engineering

Isolation of genes of economic importance. Gene constructs for tissue-specific expression. Different methods of gene transfer to plants, viz. direct and vector-mediated. Molecular analysis of transformants. RNAi technology. Cisgenesis. Molecular pharming, bioremediation. GM detection methods. Resistance management strategies for target traits. Potential applications of plant genetic engineering for crop improvement, i.e. insect-pest resistance (insect, viral, fungal and bacterial disease resistance), abiotic stress resistance, herbicide resistance, storage protein quality, increasing shelf-life, oil quality, biofortification, Genetic engineering for pollination control, Induction of male sterility in plants. Current status of transgenics, biosafety norms and controlled field trials and release of transgenics (GMOs). IPR, genome editing technique.

Unit 12: Molecular Markers and Genomics

DNA molecular markers: Principles, type and applications; restriction fragment length polymorphism (RFLP), randomly amplified polymorphic DNA sequences (RAPD), amplified fragment length polymorphism (AFLP), Simple sequence repeats (SSR), Single nucleotide polymorphism (SNP), DaRT, SRAP, TRAP markers. Structural and functional genomics, gene mapping, genome mapping-GWAS and Genomic selection, gene tagging and comparative genomics and application of genomics. TILLING and ECOTILLING applications. Development of mapping population and types of mapping populations-RILs, NILs, F2, BILs, DH, MAGIC, Mutant populations. Linkage mapping. Association mapping, Molecular mapping of complex traits and Marker Assisted Selection and other applications of markers: MABC, MARS and Genomic Selection. DNA fingerprinting and barcoding. Phylogeography, conservation genetics. DNA chips and their use in transcriptome analysis; Mutants and RNAi in functional genomics; Proteomics, Metabolomics and ionomics.