MOLECULAR BIOLOGY SYLLABUS

PRINCIPLES OF BIOTECHNOLOGY

Branches of Biotechnology

History, scope and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology *etc.* Basics of Biotechnology, Primary metabolic pathways, Enzymes and its activities.

Genetic material, rDNA technology and application

Structure of DNA, RNA and protein, their physical and chemical properties. DNA function: Expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries;Applications of gene cloning in basic and applied research.

Biotechnology in crop improvement

Molecular markers and omic technologies

Molecular analysis of nucleic acids - PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP*etc,* and their applications; DNA sequencing, different methods; Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics.

Plant tissue culture and genetic engineering

Plant cell and tissue culture techniques and their applications, Plant transformation: Gene transfer methods and applications of GM crops. Genome editing, gene silencing

Bioethics, biosafety and IPR

Bioethics, biosafety and IPR

Introduction to Emerging topics: Plant microbial interactions, Success stories in Biotechnology, Careers and employment in biotechnology. Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

FUNDAMENTALS OF MOLECULAR BIOLOGY

Nucleic acid structure, types and function

History and chemistry of nucleic acid

Historical developments of molecular biology, Nucleic acids as genetic material, Chemistry and Nomenclature of nucleic acids; Structure of DNA: primary structure; secondary structure, Forms of DNA: A,B, Z and their function; Structure and Types of RNA Genome organizationin prokaryotes and eukaryotes; DNA Topology; DNA re-association kinetics, Types of repeat sequences.

Central dogma and DNA replication and repair

Central dogma of Molecular Biology; DNA replication- Classical experiments, Models of DNA replication; DNA replication, Origin and Steps in DNA replication

– initiation, elongation and termination; Enzymes and accessory proteins and its mechanisms; Eukaryotic DNA replication in brief. Types of DNA damages and mutations; DNA repair mechanisms, Recombination: Homologous and non-homologous, Genetic consequences.

Gene expression

Prokaryotic and eukaryotic transcription
Prokaryotic transcription, initiation, elongation and termination, promoters, Structure and function of eukaryotic RNAs and ribosomal proteins. Eukaryotic transcription – RNA polymerase I, II and III, Elongation and Termination, Eukaryotic promoters and enhancers, Transcription factors,Post transcriptional processing, Splicing, Catalytic RNAs, RNA stability and transport, RNA editing.

Genetic code and translation

Genetic code and its characteristics, Universal and modified genetic code and its characteristics, Wobble hypothesis; Translational machinery; Ribosomes in prokaryotes and Eukaryotes. Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes, Elongation:translocation, transpeptidation and termination of translation; Co- andPost-translational modifications of proteins; Translational control; Protein stability -Protein turnover and degradation.

Gene regulation

Prokaryotic gene regulation
Gene regulation in prokaryotes, Constitutive and Inducible expression, small molecule regulators; Operon concept: lac and trp operons, attenuation, anti-termination, stringent control.

Eukaryotic gene regulation
Gene regulation in eukaryotes– regulatory RNA and RNA interference mechanisms, silencers, insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix etc. Epigenetic regulations.

MOLECULAR CELL BIOLOGY

Introduction and scope of cell biology

Cell theories and cell structure
Origin of life, History of cell biology, Evolution of the cell: endosymbiotic theory, tree of life, eneral structure and differences between prokaryotic and eukaryotic cell; Similarities and distinction between plant and animal cells; different kinds of cells in plant and animal tissues.

Cell and its organelles
Cell wall, cell membrane, structure and composition of biomembranes, Structure and function of major organelles: Endoplasmic reticulum Ribosomes, Golgi apparatus, Mitochondria, Chloroplasts, Lysosomes, Peroxisomes, Micro-bodies, Vacuoles, Nucleus, Cytoskeletal elements.

Cell division and communication

Cell division and apoptosis
Chromatin structure, Cell division and regulation of cell cycle; Mechanisms of cell division, olecular events at M phase, mitosis and cytokinesis, Ribosomes in relation to cell growth and division, Extracellular and intracellular Control of Cell Division; abnormal cell division: cancer- hall marks of cancer and role of oncogenes and tumor suppressor genes in cancer development - Programmed cell death (Apoptosis).

Cell-cell communication and intercellular processes
Membrane transport; Diffusion, osmosis, ion channels, active transport, mechanism of protein sorting and regulation of intracellular transport, transmembrane and vesicular transport - endocytosis and exocytosis; General principles of cell communication: hormones and their receptors, signaling through G-protein coupled receptors, enzyme linked receptors; signal transduction mechanisms and regulation, Cell junctions, Cell adhesion, Cell movement; Extracellular matrix.

Differentiation and morphogenesis

Cell differentiation and animal models
Morphogenetic movements and the shaping of the body plan, Cell diversification, cell emory, cell determination, and the concept of positional values; Differentiated cells and the maintenance of tissues and organ development; Stem cells: types and applications; Basics ofAnimal development in model organisms (C. elegans; Drosophila); Plant development.

OMICS AND SYSTEMS BIOLOGY
Omics technologies

Genomics and ionomics

Different methods of genome sequencing, principles of various sequencing chemistries, physical and genetic maps, Comparative and evolutionary genomics, Organelle genomics, applications in phylogenetics, case studies of completed genomes, preliminary genome data analysis, basics of ionomics analysis, different methods.

Proteomics

Protein-basics: primary-, secondary- and tertiary structure, Basics of X-ray crystallography and NMR, Principal and Applications of mass spectrometry, Proteomics: Gel based and gel free, Basics of software used in proteomics, MASCOT, PD-Quest, *etc.,* Study of protein interactions, Prokaryotic and yeast-based expression system and purification.

Unit III: Metabolomics and integrated omics

Metabolomics and its applications, Use of 1D/2D NMR and MS in metabolome analysis, Multivariate analysis and identification of metabolite as biomarkers, Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), X-Ray Fluorescence (XRF),Neutron activation analysis (NAA), Data integration using genome, transcriptome, proteome, metabolome and ionome with phenome.

Systems Biology

Introduction to systems biology and regulatory networks

Introductory systems Biology - The biochemical models, genetic models and systems model, olecules to Pathway, equilibrium binding and cooperatively - Michaelis - Menten kinetics, Biological oscillators, genetic oscillators, quorum sensing, cell-cell communication, Drosophiladevelopment, pathways to network, gene regulation at a single cell level, transcription network, Regulatory Circuits, Negative and positive autoregulation, alternative stable States, bimodal switches, network building and analysis.

PLANT GENETIC ENGINEERING

Tools for genetic engineering

Requirement for genetic engineering including Enzymes, Probes and Vectors

Historical Requirement background, Restriction Enzymes; DNA Modifying enzymes, ligase, T4 DNA polymerase, Polynucleotide kinase *etc,* Cohesive and blunt end ligation; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Plasmids; Bacteriophages; M13, Phagemids; Lambda vectors; Insertion and

Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; Expression vectors; pMal, pET-based vectors; Baculovirus vectors system, Plant based vectors, Tiand Ri plasmids as vectors, Yeast vectors, Shuttle vectors.

Gene cloning, transformation and Transfection methods

Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning, Jumping and hopping libraries, Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing geneexpression; Codon optimization for heterologous expression. Introduction of DNA into mammalian cells; Transfection techniques.

Detection of transgene integration and expression

PCR and its variants

Principles of PCR, Primer design, DNA polymerases, Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T- vectors; Applications of PCR in gene recombination, Protein purification; Histag;GST-tag; MBP-tag, *etc.*;

Mutagenesis and detection of mutations

Site specific mutagenesis, molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay.

DNA and Protein based Hybridization detection methods

Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence *in situ h*ybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions: Electromobility shift assay

Plant genetic transformation
Requirements and methods of plant Transformation

Genetic transformation of plants: Vectors and transgene design - Promoters and Marker genes. Indirect DNA delivery – *Agrobacterium* mediated method. Direct DNA delivery – Chemical mediated Electroporation and Particle bombardment (Gene gun) method.
Chloroplast mediated transformation.

Analysis of transgenic plants and advanced methods in plant genetic engineering

Development of marker-free plants. Analysis of transgenic plants – molecular and Biochemical assays, genetic analysis - Identification of gene integration site - Advance methods – cis genesis, Intragenesis and targeted genome modification – ZFN, TALENS and CRISPR. Application of transgenic technology.

INTRODUCTION TO BIOINFORMATICS

Overview, scope and importance of Bioinformatics

Biological databases

Bioinformatics basics, scope and importance of bioinformatics; Biological databases for DNA and Protein sequences -PIR, SWISSPROT, GenBank, DDBJ, secondary database, structural databases –PDB,SCOP and CATH, Specialized genomic resources, Microarray database.

Gene sequence and structure analysis

Bioinformatics Tools Facilitate the Genome-Wide Identification of Protein-Coding Genes, Sequence analysis, Sequence submission and retrieval system-SEQUIN, BANKit, SAKURA, Webin, Sequence alignment, pair wise alignment techniques, multiple sequence alignment; Tools for Sequence alignment- BLAST and its variants; Phylogenetic analysis- CLUSTAL X, CLUSTAL W, Phylip, Tcoffee.

Proteomics and drug discovery

Protein structure and function prediction

Sequencing of protein; Protein secondary structure prediction- Chousfasman, GOR Method, Protein 3DStructure Prediction: Evaluation of models- Structure validation and refinement - Ramachandran plot, Force field calculations, SAVES. Protein function prediction- sequence and domain based, Primer designing-principles and methods.

Drug discovery
Drug discovery, structure based drug design - rationale for computer aided drug designing, basic principles, docking, QSAR.

PLANT TISSUE CULTURE

Plant tissue culture techniques and applications

History, concepts and scope of tissue culture
History of plant tissue culture, principle of Totipotency; Tissue culture media; Plant hormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of plant tissue culture;

Methods of plant tissue culture
Micropropagation of field and ornamental crops; Virus elimination by meristem culture, meristem tip culture and micrografting; Androgenesis and gynogenesis - production of androgenic and gynogenic haploids - diploidization; protoplast culture - isolation and purification; Protoplast culture; protoplast fusion; Somatic hybridization – Production of somatic hybrids and cybrids, Somatic embryogenesis and artificial seeds, Wide hybridization - embryo culture and embryo rescue techniques; Ovule, ovary culture and endosperm culture.

Callus and cell suspension culture

Cell suspension culture for secondary metabolite production
Large-scale cell suspension culture - Production of alkaloids and other secondary metabolites-techniques to enhance secondary metabolite production

Somaclonal variations
Somaclonal and gametoclonal variations – causes and applications;Callus culture and in vitro screening for stress tolerance;

Germplasm conservation

In vitro germplasm storage and cryo-preservation.
Commercial plant tissue culture

Case studies/success stories
Commercial Tissue Culture: Case studies and success stories.

Genetic purity testing and virus indexing

National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods – PCR, ELISA, Market assessment; project planning and preparation, economics, government policies.

MICROBIAL AND INDUSTRIAL BIOTECHNOLOGY

Scope and applications of Industrial Biotechnology

Industrially important microbes, screening and improvement

Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms. Strategies for development of industrial microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry.

Production of industrially important metabolites

Primary metabolites, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non-ribosomalpeptide antibiotics as case study; Recombinant DNA technologies for microbial processes.

Microbial enzymes and immobilization

Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio- augmentation with production of vitamin C as a case study; Bioreactors, their design and types; Immobilized enzymes-based bioreactors; Microencapsulation technologies for immobilization of microbial enzymes.

Environmental Biotechnology

Biotreatment, Bioremediation and waste management

Environmental Biotechnology, biotreatment for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bio-transformations, Bioremediation of soil; Production of eco-friendly agricultural chemicals, bio- pesticides, bio-herbicides, bio-fertilizers, bio-fuels, *etc.*

MOLECULAR PLANT BREEDING

Mapping population and Molecular markers

Inheritance of traits, heritability and development of mapping population

Inheritance of qualitative and quantitative traits. Heritability – its estimation, Population structure of self- and cross-pollinated species, Factors affecting selection efficiency. Development of different kinds ofsegregating populations – F2, F3, BC1F1, BC1F2, BC4F2, RIL (Recombinant Inbred Lines), AIL (Advanced Intercrossed Lines), DH (Di-haploid population), NIL (Near Isogenic lines), NAM (Nested Association Mapping), MAGIC (Multi-parent Advanced Generation Intercross population).

Molecular markers and linkage map construction

Causes of sequence variation and its types, Types of molecular markers and development of sequence based molecular markers – RFLP, AFLP, SCARs, CAPS,

SSRs, STMS, SNPsInDel and DARTseq; Inheritance of markers, Linkage analysis using test cross, F2, F3, BC1F1,RIL. Construction of genetic map, Mapping genes for qualitative traits;Genotyping by sequencing and high-density chip arrays.

QTL mapping

QTL mapping and GWAS
QTL mapping using structured populations; Association mapping using unstructured populations; Genome Wide Association Studies (GWAS),Principle of Association mapping– GWAS-SNP genotyping methods, Fine mapping of genes/QTL; Development of gene based markers; Allele mining by TILLING and Eco-TILLING.

Genotying by sequencing
DART array sequencing, Illumina's Golden Gate Technology, Genotyping by sequencing methods- Fluidigm; GBS, Illumina Hi seq- Nano pore sequencing, Principles and methods of Genomic election.

Applications of molecular markers in crop improvement

Marker-Assisted selection and gene introgression
Tagging and mapping of genes. Bulk segregant and co-segregation analysis, Marker assisted selection (MAS); Linked, unlinked, recombinant, flanking, peak markers. Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specifictraits with examples. Haplotype concept and Haplotype-based breeding;Genetic variability and DNA fingerprinting. Molecular markers in Plantvariety protection, IPR issues, hybrid purity testing, clonal fidelity testing and transgenic testing.

IPR, BIO-SAFETY & BIOETHICS

Intellectual property rights

IPR, types of IPR and patents in biotechnology
IPR: historical background in India; trade secret; patent, trademark, design& licensing; procedure for patent application in India; Patent Cooperation Treaty (PCT); Examples of patents in biotechnology-Case studies in India and abroad; copyright and PVP.

Implications of IPR for commercialization and trade agreements
Implications of IPR on the commercialization of biotechnology products, ecological implications; Trade agreements- The WTO and other international agreements, and Cross border movement of germplasms.

Biosafety and bioethics

Biosafety, biohazard, risk assessment, regulatory protocols and guidelines
Biosafety and bio-hazards; General principles for the laboratory and environmental bio-safety; Biosafety and risk assessment issues; handling and disposal of biohazards; Approved regulatory laboratory practice and principles, The Cartagena Protocol on biosafety; Biosafety regulations in India; National

Biosafety Policy and Law; Regulationsand Guidelines related to Biosafety in other countries.

Concerns of transgenic plants, risk and safety assessment
Potential concerns of transgenic plants – Environmental safety and food and feed safety. Principles of safety assessment of transgenic plants – sequential steps in risk assessment. Concepts of familiarity and substantial equivalence. Risk - Environmental risk assessment –invasiveness, weediness, gene flow, horizontal gene transfer, impact on non-target organisms; food and feed safety assessment –toxicity and allergenicity.

Unit III: Monitoring and detection of transgenics and Bioethical issues
Monitoring strategies and methods for detecting transgenics. Field trails, biosafety research trials, standard operating procedures, labelling of GM food and crop, Bio-ethics. Mankind and religion, social, spiritual & environmental ethics; Ethics in Biotechnology, labeling of GM food and crop; Biopiracy.

IMMUNOLOGY AND MOLECULAR DIAGNOSTICS

Immune system

Types of Immunity and immune system
Immunity and its classification; Components of innate and acquired immunity; Lymphatic system; Hematopoiesis; Organs and cells of the immune system-primary, secondary and tertiary lymphoid organs Descriptions of Antigens – immunogens, hapten and adjuvants.

Immunoglobulins and diversity

Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily;Principles of cell signaling; Basis of self and non-selfdiscrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cluster ofDifferentiations (CDs), Cytokines-properties, receptors and therapeutic uses.

Unit III: Antigens and Immune response
Phagocytosis; Complement and Inflammatory responses; Major Histocompatibility Complex-MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing; Antigen processing and presentation-endogenous antigens, exogenous antigens,non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten-carrier system.

Molecular Diagnostics

Immunological techniques

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques – RIA, ELISA, Westernblotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosenor assays for assessing ligand –receptor

interaction, CMI techniques lympho proliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, Transgenic mice, Gene knock outs.

Vaccines and immune therapies

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants,recombinant DNA and protein based vaccines, plant-based vaccines, Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies, Immunity to Infection,Bacteria, viral, fungal and parasitic infections, Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases, MHC and TCR in autoimmunity; Transplantation, Immunological basis of graft rejection, immunosuppressive therapy; Tumor immunology – Tumor antigens.

NANO BIOTECHNOLOGY

Overview of nanobiotechnology and nanomaterials

Nanomaterial synthesis and characterization

Introduction to Nanotechnology - Nanomaterials - Self-assembly to artificial assembly for creation of useful nanostructures – Bottoms up and Top down approach (Nano rods, nano cages, nanotubes, quantum dots, nanowires, metal/ polymer-based nanostructures) – Preparation and Characterization of nanoparticles (particle size analyzer, microscopy, *viz.* electron microscopy, atomic force microscopy, etc).

Bionanomaterials

Cell structure – Bio macromolecules: Types, Structure, Dynamics and interaction with water – Cellular nano machines – cellular transducers, membrane channels, membrane transporters, Membrane motors – Creation of bio-nanostructures (Nano liposomes, Nano micelles, Nanomotors, *etc.*).

Properties of nanomaterial

Chemical, physical and biological properties of biomaterials and bio response: biomineralization, biosynthesis, and properties of natural materials (proteins, DNA and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems.

Applications of nanotechnology

Biosensors and nanocarriers
Nano particular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Micro fabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

ENVIRONMENTAL BIOTECHNOLOGY
Scope and Importance of Biotechnology in environment Unit I: Environmental pollution and control

Basic concepts and environmental issues; types of environmental pollution; problems arising from high-input agriculture; methodology of environmental management; air and water pollution and its control;waste water treatment - physical, chemical and biological processes;need for water and natural resource management.

Applications of Microorganisms in pollution control

Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides and toxic chemicals,detergents *etc*;

Energy sources and Waste water treatment

Energy, Biofuels and Biofertilizer

Renewable and non-Renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas; microbial hydrogen production; conversion of sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture *etc.*

Waste water treatment

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, *etc*); anaerobic processes: digestion, filtration, etc.bioleaching; enrichment of ores bymicroorganisms; global environmental problems: ozone depletion, UVB,greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

BIO-ENTREPRENEURSHIP

Scope and Importance of Bio-entrepreneurship

Overview of bio-industries and entrepreneurship development programs

Scope in biotechnology; types of bio-industries – bio-pharma, bioagri,bio-services and bio-industrial; Importance of entrepreneurship; introduction to bioentrepreneurship – biotechnology in a global scale; – skills for successful entrepreneur–creativity, leadership, managerial, team building, decision making; opportunities for bio-entrepreneurshipentrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India).

Business development and SWOT analysis

Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/ support from various agencies; statutory and legal requirements for starting a company/ venture.

Incubation and Market linkages

Incubation and technology transfer

Knowledge centers e.g., in Universities, innovation centres, research institutions (public & private) and business incubators; R&D for technology development and upgradation; assessment of technology development; managing technology transfer.

Market study and analysis

Entry and exit strategy; identifying needs of customers; Market linkages, branding issues; developing distribution channels - franchising; policies, promotion, advertising; branding and market linkages for 'virtual startup company'. Pricing strategy.

STRESS BIOLOGY AND GENOMICS

Stress Biology and Stress response

Kinds of stresses and adaptation strategies

Different kinds of stresses (biotic and abiotic) and adaptation strategies: Plant cell as a sensor of environmental changes; role of cell membranes in signal perception; Ways of signal transduction in cells and whole plants as a response to external factors. Abiotic stresses affecting plant productivity – Drought, salinity, water logging, temperature stresses, light stress and nutrient stress; Drought stress –Effects on plant growth and development; Components of drought resistance; Physiological, biochemical and molecular basis of tolerance mechanisms; Biotic stress (insect and pathogen) resistance mechanism.

Drought stress

Strategies to manipulate drought tolerance – Osmotic adjustment and Osmoprotectants - synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants; hormonal metabolism - ABA signaling; signaling components – transcription factors. Water logging stress – effects on plant growth and metabolism; adaptation to water logging,tolerance mechanisms -hormones and flooding tolerance. Strategies for improving submergence tolerance.

Salinity and heavy metal stress

Salinity stress – effects on physiology and metabolism of plants, SOS pathways and ion homeostasis, Strategies to improve salinity tolerance in plants. Water logging stress – effects on plant growth and metabolism; tolerance mechanisms. Physiological and biochemical changes – High & Low temperature tolerance mechanisms – molecular basis of thermo tolerance. Morphological and physiological changes in plants due to high and low light stresses - photo oxidation –plastid development. Characters of heliophytes and sciophytes – solar tracking – sieve effect and light channeling. Heavy metal stress – Al and Cd stress - effects on plant growth and development, Strategies to overcome heavy metal stress Nutrient stress-effects on plant growth and development. Genetic manipulation strategies to overcome the stress effects.

Advanced techniques for stress tolerance

Genomics and transgenic approaches for stress management

Transfer of tolerance/resistant genes to model plants and validation of gene function. Different techniques for the functional validation of genes. Signaling pathway related to defense gene expression, R proteins, RNAi approach and genes

from pathogens and other sources, coat protein genes, detoxification genes, transgenic and disease management. Bt proteins, resistance management strategies in transgenic crops, ecological impact of field release of transgenic crops. Genomics; transcriptomes, small RNAs and epigenomes; functional genomics;

Bioinformatics for stress management
Bioinformatics approaches to determine gene function and network in model plants under stress.

GENE REGULATION

Transcriptional regulation and regulatory factors

Transcriptional regulation - cis- and trans-acting factors

Transcriptional regulation – Regulatory proteins, Activators and Repressors, Binding of RNA polymerase, Allosteric regulation, DNA looping, Cooperative binding, Anti-termination, Combinatorial control – Regulation of lac, trp and ara Operons. Gene regulation in Lambda phage – lytic or lysogenic establishment.

Regulatory sequences and signal transduction

Regulatory sequences – Promoters, Enhancers, Silencers, Insulators, Locus Control Region. Activator proteins and their binding sites, DNA binding domain– Homeodomain, Zinc containing proteins, Leucine Zipper Motif, Helix-Loop-Helix, HMG proteins. Recruitment of RNA polymerase to promoter region, Nucleosomes and their modifiers. Signalintegration. Signal transduction and transcriptional regulation. Gene Silencing. Epigenetic gene regulation.

Non-coding RNA and gene regulation

Non-coding RNAs

Regulation by RNA in prokaryotes and eukaryotes, RNA as defense agents. Ribo-switches. Gene Silencing by RNA - siRNA & miRNA – synthesis and function. Non-coding RNAs their impact, categories and role in gene regulation, chromatin assembly *etc.*

Auto-regulation
Negative auto-regulation, Positive auto-regulation, Bistable and Bimodal switch, Oscillating pattern of gene expression.