**PROGRAMME**

**B.Tech. (Biotechnology)**

## DESCRIPTION OF COURSE CONTENTS

**Biotech. 51 Elementary Plant Tissue Culture 1+1 Sem. II**

History and development of plant tissue culture. Introduction, scope and importance of plant tissue culture. Advantages and disadvantages of *in vitro* propagation. Nutritional requirements of *in vitro* cultures. Mother plant selection, and collection, preparation, surface sterilization and inoculation of explants. *In-vitro* propagation *via* enhanced release of axillary buds. Organogenesis and somatic embryogenesis. Economics and commercial potential of *in-vitro* propagation. Progress in the *in-vitro* propagation of field, forestry and horticultural plants.

**Practical**: Lay out of *in-vitro* propagation units. Working inside *in-vitro* propagation unit. Laboratory organization, equipment, tools and techniques. Laboratory contaminants - its control measures. Culture media preparation: major nutrients, minor nutrients, organics and other ingredients. Plant growth regulators. Solidifying agents, methods of sterilization, inoculation and incubation of cultures. *Ex-vitro* establishment of plantlets, their field testing, field planting and management of tissue culture plants.

**Biotech. 101 Cell Biology 2+0 Sem. I**

Origin and evolution of cell. Introduction to microscopy. Sub-cellular structure of prokaryotic and eukaryotic cells. Membrane structure and function: plasma membrane, cell wall and extracellular matrix. Structural organization and function of intracellular organelles and organelle biogenesis. Nucleus, mitochondria, endoplasmic reticulum, golgi apparatus, lysosomes, peroxisomes, plastids, vacuoles. Structure and function of cytoskeleton and its role in motility. Cell membrane transport. Introduction to cell signalling. Cell growth, cell cycle and its control. Cell death and cell renewal.

**Biotech. 102 Molecular Biology 2+1 Sem. II**

History of molecular biology. Central dogma of life. Structure of DNA and RNA. Gene structure and function. DNA replication. Transcription. Genetic code and translation. Structure of prokaryotic and eukaryotic nuclear and organelle genomes. Gene regulation in prokaryotes: Lac operon concept, Tryp concept, Introduction to microbial genetics. Conjugation, transformation and transduction. Tools in molecular biology. Role of enzymes in molecular biology. Principles of Polymerase Chain Reaction. Electrophoresis. PCR and hybridization based molecular markers.

**Practical:** Preparation of bacterial competent cells and transformation. Isolation and purification of plant and animal DNA. Measurement of nucleic acid concentration using spectrophotometer and gel electrophoresis. DNA amplification using RAPD, microsatellite primers and analysis. CAPS primers. Generation of linkage maps and mapping of qualitative genes. Estimation of genetic similarities and generation of dendrograms.

**Biotech. 103 Introduction to Biotechnology 2+1 Sem. I**

History, definitions, concepts, scope and importance of Biotechnology - plant, microbial, animal, medical, environmental, industrial, marine, agricultural and food biotechnology. Nano biotechnology. Introduction to recombinant DNA technology and its applications-vectors, DNA restriction and modifying enzymes, gene cloning. Introduction to genomics and proteomics: Molecular markers, DNA sequencing. Genetic transformation and transgenic organisms. Bioinformatics. Biosafety guidelines.

Practical: Orientation to the laboratories: glass houses, screen houses, transgenic facilities and field area. General guidelines for working in biotechnology laboratory. Familiarization with basic equipments used in biotechnology. Selection of chemicals (different grade), buffer preparation, calculations and scientific notations used in laboratories.

**Biotech. 104 Plant Tissue Culture 2+1 Sem. II**

History of plant tissue culture. Concept of totipotency. Concept of aseptic culture practices. Components of *in vitro* culture media and role of different macro and micro nutrients, vitamins, plant growth regulators and growth supplements. Sterilization techniques. Various pant cell, tissue and organ culture techniques and uses. Somatic cell cultures. Morphogenesis - organogenesis and somatic embryogenesis. Micropropagation - *in vito* grafting, meristem culture. Anther, pollen, embryo, ovule, ovary culture. Protoplast culture and somatic hybridization. Somaclonal variation.

**Practical:** Good laboratory practices. Media preparation and sterilization. Surface sterilization of explants. Establishment of callus/ cell suspension cultures. Micropropagation. Embryo culture. Anther and pollen culture. Induction of plant regeneration. Hardening and transfer to soil.

**Biotech. 106 Electronics and Instrumentation in Biotechnology 1+1 Sem. II**

Electronics, PN junction diode, diode forward and reverse characteristics. Diode as circuit element. Application of junction diode - half wave, full wave bridge rectifier, clipper, clamper, voltage multiplier circuit. Construction and working of bipolar transistor, load line concept, design of biasing methods of NPN transistor, AC model, analysis of small signal NPN transistor. Concept of instrumentation system. Transducers for temperature measurement, linear displacement measurement using LVDT. Force measurement using strain gauge. Principles, working of table top, refrigerated and ultra-centrifuges, laminar air flow, autoclaves, pH meter, fermenters, temperature control and BOD shakers, gel electrophoresis, 2-D gel electrophoresis, gel documentation, gel driers, ELISA readers, lypholizers, spectrophotometers, gene pulser, particle gun, growth chambers, thermal cyclers, Real time PCR, DNA synthesizer and sequencer. Microscopes.

**Practical:** Familiarization with laboratory equipment and equipment working. Forward and reverse characteristics of a PN junction diode. Study of half wave, full wave, bridge rectifier using diode. Clipper, clamper and voltage multiplier circuit. Determination of input V-I characteristics of bipolar transistor for common emitter configuration. Determination of output V-I characteristics of bipolar transistor for common emitter configuration. Analysis of a biasing circuit for CE transistor. Design and test a biasing circuit for CE transistor. Study the measure of temperature using available sensor. Measurement of displacement with the available sensor. Study force with the available sensor.

**Biotech. 202 Introductory Bioinformatics 2+1 Sem. I**

Introduction to bioinformatics. Development and scope of bioinformatics. Applications of computers in bioinformatics. Operating systems, hardware, software, Internet, world wide web resources and FTP. Primary databases - nucleotide sequence databases (GenBank, EMBL), protein sequence databases. Secondary databases - SwissProt/TrEMBL, conserved domain database, Pfam. Structure databases - Protein Data Bank (PDB), MMDB, SCOP, CATH. File formats - Genbank, EMBL, Fasta, PDB, Flat file, ASN.1, XML. Introduction to sequence alignment and its applications - pair wise and multiple sequence alignment, concept of local and global alignment. Algorithms - Dot Matrix method, dynamic programming methods (Needleman–Wunsch and Smith–Waterman). Tools of MSA-ClustalW, TCoffee. Phylogeny. Introduction to BLAST and FASTA.

**Practical**: Basic computing - Introduction to UNIX, LINUX. Nucleotide information resource - EMBL, GenBank, DDBJ, Unigene. Protein information resource - SwissProt, TrEMBL, Uniprot. Structure databases - PDB, MMDB. Search engines - Entrez, ARSA, SRS. Similarity searching - BLAST and interpreting results. Multiple sequence alignment - ClustalW. Structure visualization of DNA and proteins using Rasmol.

**Biotech. 201 Recombinant DNA Technology 2+1 Sem. II**

Recombinant DNA technology. Restriction endonucleases - types and uses. DNA ligases. Vectors - plasmids, cosmids, phagemids, bacterial artificial chromosomes (BACs), P1-derived

artificial chromosomes (PACs), yeast artificial chromosomes (YACs), transposon vectors, expression vectors, shuttle vectors, binary plant vectors, co-integrating vectors. Construction and applications of chimeric DNA, Competent cells. Gene isolation and cloning. Genetic transformation of *E. coli*. Gel electrophoresis. Preparation of probes. Southern blotting. Northern blotting. Western blotting. PCR and *in vitro* gene amplification.
Practical: Orientation to recombinant DNA lab. Preparation of stock solutions and buffers. Plasmid DNA isolation. Genomic DNA isolation. Quality and quantity determination of DNA. Restriction digestion of DNA. Agarose gel electrophoresis, SDS-PAGE. PCR. Genetic transformation of *E. coli*. Screening of recombinant DNA clones in *E. coli*.

**Biotech. 203 Plant Genetic Transformation 2+1 Sem. II**

History of plant genetic transformation. Generation of gene construct and maintenance. Methods of genetic transformation - *Agrobacterium* mediated, biolistics, electroporation, liposome, Polyethylene glycol, *In planta* methods. Selection and characterization of transgenic plants using selectable and reportable markers. PCR, qRT-PCR, Southern, Northern, ELISA and Western techniques. Application of genetic transformation for developing transgenics for quality, yield, biotic and abiotic stresses. Biosafety aspects of transgenic plants and regulatory framework.
**Practical:** Preparation of stock solutions and buffers for genetic transformation. Preparation of competent cells of *Agrobacterium tumefaciens*. Restriction mapping of plasmid. Construction of binary vector and its transfer to an *Agrobacterium* strain. Confirmation of transformed bacterial colonies. *Agrobacterium tumefaciens* mediated and biolistic plant transformation. Colony hybridization.

**Biotech. 204 Classical and Molecular Cytogenetics 2+1 Sem. II**

Introduction and history. Mitosis and meiosis. Structure of chromatin. Chromosome structure and chromosome landmarks. Specialized chromosomes. Differential staining of the chromosomes - Q-banding, G-banding, C-banding and R banding. *In situ* hybridization - FISH, GISH. Changes in chromosome number. Aneuploidy - monosomy, trisomy and tetrasomy. Haploidy. Polyploidy - autopolyploidy and allopolyploidy. Methods of doubled haploid production. Structural aberrations of chromosomes - deletions, duplications, inversions and translocations. Locating genes on chromosomes. Genome analysis.
**Practical:** Preparation of chromosome stains. Testing of pollen fertility. Preparation of mitotic and meiotic slides of onion, pearl millet, wheat etc. Preparation of karyotypes. C/G banding of the chromosomes. Genomic *in situ* hybridization. Microphotography.

**Biotech. 206 Fundamentals of Plant Biotechnology 2+1 Sem. II**

Concepts and history. Various aspects of plant tissue culture. Somatic embryogenesis. Meristem culture. Micropropagation. Somaclonal variation. Anther and pollen culture. Embryo/ovule/ovary and endosperm culture. Protoplast culture and somatic hybridization. Cryopreservation of germplasm. Recombinant DNA technology. Gene cloning approaches. Methods of Genetic Transformation. Genetic Engineering. Southern, Northern and Western Hybridization. Polymerase Chain Reaction and its variants. Hybridization and PCR based DNA markers. Gene and QTL mapping. Marker assisted selection for precision plant breeding. Examples of marker assisted selection in commercial agriculture. Introduction to bioinformatics.
**Practical:** Culture media preparation. Surface sterilization of explants. Establishment of callus/cell suspension cultures. Induction of plant regeneration. Hardening and transfer to soil. Micropropagation. Embryo culture. Demonstration of gene transfer techniques. Isolation of plant DNA. Measurement of nucleic acids concentration using photo spectrometer and gel electrophoresis. PCR. DNA amplification using microsatellite primers and its fractionation using agarose gels. Introduction to various databases.

**Biotech. 301 Molecular Genetics 2+0 Sem. I**

Structures, properties and modifications of DNA. Molecular mechanism of DNA replication, repair, mutation and recombination. Centromere and telomere sequences and DNA packaging. Synthesis and processing of RNA and proteins. Regulation of gene expression. Mutations and DNA repair. Repetitive DNA sequences and transposable elements. Promoters and their isolation. Transcription factors – their classification and role in gene expression. Epigenetic control of gene expression. Small RNAs, RNA interference and its applications.

**Biotech. 302 Nanobiotechnology 2+0 Sem. I**

Introduction to nanotechnology. Concepts and terminology. Types of nanomaterials and their synthesis approaches. Nano-bio interface. Factors affecting interactions at the nano-bio interface. Biological based nanosystems, molecular motors and their types, biosensors and other devices, applications of biosensors in agriculture. Self assembly of molecules for nanotechnology applications. Biomimetics, Biotemplating and *de novo* designed nanostructures and materials. DNA-Nanotechnology. DNA computers. Nanomanipulations, material design, synthesis and their applications.

**Biotech. 303 Molecular Marker Technology 2+0 Sem. I**

Types of molecular markers - RFLP. PCR based markers - RAPD, SCAR, SSR, STS, CAPS, AFLP, SNP and their variants. Uses of molecular markers - application as genetic tools for genotyping and gene mapping. Mapping populations - $F_2$, DH, RILs and NILs. Bulked segregant analysis. Linkage maps. Physical maps. Application of molecular markers - assessing genetic diversity, variety protection, Marker-assisted breeding for accelerated introgression of transgene, major genes and quantitative trait loci (QTLs). Human and animal health - association with genetic-based diseases. Paternity determination. Forensic studies.

**Biotech. 304 Genomics and Proteomics 3+0 Sem. I**

Introduction to genomics, functional genomics and proteomics. Structural genomics. Classical ways of genome analysis, BAC and YAC libraries. Physical mapping of genomes. Next generation sequencing. Genome analysis and gene annotation. Genome projects - *E. coli*, Arabidopsis, Bovine, Human. Comparative genomics - orthologous and paralogous sequences, synteny, gene order, phylogenetic foot printing. Functional genomics. Differential gene expression techniques - ESTs, cDNA-AFLP, microarray, differential display, SAGE, RNAseq, Real time PCREDIT. Introduction to proteomics. Analysis of proteome - native poly acrylamide gel electrophoresis (PAGE), sodium dodecyl sulphate-poly acrylamide gel electrophoresis (SDS PAGE), 2D poly acrylamide gel electrophoresis (PAGE). Edmann degradation. Chromatographic techniques – high performance liquid chromatography (HPLC), gas chromatography (GC). Mass spectrometry – matrix associated laser desorption/ionization-time of flight (MALDI-TOF), liquid chromatography mass spectrometry (LC-MS). Post translational modifications.

**Biotech. 305 Biosafety, Bioethics and IPR 2+0 Sem. I**

Biodiversity definition, importance and geographical causes for diversity. Species and population biodiversity, maintenance of ecological biodiversity hot spots in India. Convention on biological diversity. Cartagena protocol of bio-safety. Risk management for GMOs. Bio-safety guidelines, rules and regulations and regulatory frame work for GMOs in India. Introduction to Intellectual Property, concepts and types. International treaties for protection of IPs. Indian legislations for the protection of various types of Intellectual Property. Patent search, filing process. Material transfer agreements.

**Biotech. 306 Computational Biology 2+1 Sem. II**

Introduction to computational biology. Web based servers and software for genome analysis: Ensembl, UCSC genome browser, MUMMER, BLASTZ. Sequence submission. Protein interaction databases: BIND, DIP, GRID, STRING, PRIDE. Principles of protein structure prediction. Fold recognition (threading). Homology modelling. SCOP, CATH, PDB,

PROSITE, PFAM. Methods for comparison of 3D structures of proteins. Phylogenetic analysis: Evolutionary models, tree construction methods, statistical evaluation of tree methods. PHYLIP, dendroscope, MEGA. DNA barcoding database - BOLD.
Practical: Application of genome browsers in genomic research. Exploring protein-protein interaction databases. Working with protein structural classification databases. SCOP, CATH, PDB, PSD databases. SNP and SSR identification tools. PHYLIP. Genome browsers, microarray databases.

**Biotech. 307 Micropropagation Technologies 1+2 Sem. II**

Introduction to tissue culture and micropropgation techniques, their limitations and applications. Types of cultures - seed, embryo, organ, callus, cell. Stages of micropropagation. Axillary bud proliferation - shoot tip, meristem and bud cultures. Organogenesis - callus and direct organ formation. Somatic embryogenesis. Cell suspension cultures. Production of secondary metabolites. Somaclonal variation. Cryopreservation.
**Practical:** Nutrient media composition and preparation for specific cultures. Sterilization techniques for explants. Callus induction. Induction of somatic embryos. Regeneration of whole plants from different explants. Micropropagation of sugarcane, mentha, banana and citrus. Hardening procedures.

**Biotech. 308 Food Biotechnology 2+1 Sem. II**

(For students of B.Tech. Food Technology)
Chemical nature, properties and functions of the genetic material. Organization of the genetic material in prokaryotes and eukaryotes. DNA replication. Transcription and translation - types of RNA and genetic code. Mutation and DNA repair. Genetic recombination in bacteria, transformation, transduction, conjugation. Regulation of gene expression in prokaryotes. Recombinant DNA technology - Restriction enzymes, cloning vectors, cloning procedures, Gene cloning. Biosensors - classification, application in food industry. Application of biotechnology in food - immobilization of enzymes, arresting of cell in insoluble matrix, immobilized cell systems, cell attachment in a surface, aggregation, entrapment, containment, physical adsorption, covalent bonding, cross linking, entrapment into polymeric films, microencapsulation, large scale cell immobilization, uses and applications in industries. Ethical issues concerning GM foods. Testing for GMOs, bio-safety guidelines, risk assessment and risk management. Public perception of GM foods.
**Practical:** Study of auxotroph. Micro-propagation through tissue culture. Isolation and analysis of chromosomal/genomic DNA from *E. coli* and *Bacillus cereus*. Separation of protoplast using cellulytic enzymes. Production of biomass from fruit and vegetable waste. Introduction of ELISA, Southern blot. DNA finger printing. Agarose gel electrophoresis of plasmid DNA. Pesticide degradation by *Pseudomonas* spp.

**Biotech. 309 Nutrigenomics 3+0 Sem. II**

(For students of B. Sc. (Hons.) Nutrition and Dietetics)
Genomics - Definition, scope and importance. Global impact of genomics. Genomics in health care, agriculture and environment. Processes and products of biotechnology. Application of genomics in development of nutritious foods. Genes - nature, concept and synthesis. Chemical nature of DNA, nucleotides and nucleosides. Structure of RNA and RNA splicing. Units of gene, gene expression, regulation and transcription. Epigenetic changes in relation to diet. Genetic engineering for human health. Gene therapy and personalized medicine. Single cell protein. Role of genomics in enzymology and product development. Genetic improvement of food grade microorganisms. Nutritional significance of food products developed by biotechnological techniques. Scientific, technological and resource constraints on genomics. Factors affecting development in nutri genomics.

**Biotech. 310 Applications of Genomics and Proteomics 2+1 Sem. II**

Structure of genomes - *Arabidopsis*, pigeonpea, rice, tomato, wheat. DNA chips and their use in transcriptome analysis. Mutants and RNA interference (RNAi) in functional genomics. Site

directed mutagenesis. Transposon tagging. Transient gene expression – virus induced gene silencing (VIGS) and florescence activated cell sorting (FACS) based targeted genome editing technologies. Bio-informatics in proteomics - protein 3D structure modelling (Homology modelling and crystallography). Proteome analysis. Protein-protein interaction - FRET, yeast two hybrid and co-immunoprecipitation. Applications of genomics and proteomics in agriculture, human health and industry. Metabolomics and ionomics for elucidating metabolic pathways.

**Practical:** SDS-PAGE. 2D electrophoresis. Protein characterization through HPLC. Specialized crop based genomic resources - TAIR, Gramene, Graingenes, Maizedb, Phytozome, Cerealdb, Citrusdb. miRbase.

**Biotech. 311 Molecular Breeding 2+1 Sem. II**

Principles of Plant Breeding. Breeding methods for self and cross-pollinated crops. Heterosis breeding. Limitations of conventional breeding. Methods of fruit crop improvement.

Challenges in horticultural crop breeding, Pseudo test cross strategy for perennials with long juvenile period. Development of specific mapping populations.

QTL mapping using structured populations. Fine mapping of genes/QTL. Map based gene/QTL isolation and development of gene based markers. Marker assisted selection (MAS) - foreground and background selection. MAS for major and minor genes. Marker assisted pyramiding. Marker assisted recurrent selection. Transgenic breeding. MAS for specific traits with examples. Commercial applications of MAS.

**Practical:** Working on some genotyping and phenotyping datasets for Linkage mapping using Mapmaker, MapDisto and QTL mapping softwares - WinQTL cartographer. Use of gene based and closely linked markers for foreground selection for target traits in target crops. Marker assisted detection of the transgene.

**Biotech. 312 Epigenetics and Gene Regulation 3+0 Sem. II**

DNA methylation and histone modifications. DNA methylases, methyl binding proteins and histone modifiers. Epigenetic changes in response to external stimuli leading to changes in gene regulation. Role of DNA methylation in plant development. Mutant case studies. Introduction to small RNAs. History, biogenesis. *In silico* predictions of miRNAs, target gene identification, methylation of heterochromatin by het associated siRNAs. Small RNAs electrophoresis using PAGE. Blotting of small RNAs on nylon membrane. Detection of small RNAs using fluorescent labelled probes. Gene regulation by small RNA. Other classes of siRNAs. Bisulphite sequencing for methylation detection. Role of small RNAs in epigenetics. Jacob Monod model of gene regulation. RNA editing, Genome imprinting.

**Biotech. 313 Programming for Bioinformatics 2+2 Sem. II**

Introduction - operating systems, programming concepts, algorithms, flow chart, programming languages, compiler and interpreter; Computer number format - Decimal, Binary, Octal and Hexadecimal. C-language: History, constant, variables and identifiers, character set, logical and relational operators, data input and output concepts; Decision making: if statement, if-else statement, for loop, while loop, do-while loop, arrays and functions, file handling. PERL-language - Introduction, variables, arrays, string, hash, sub-routines, file handling, conditional blocks, loops string operators and manipulators.

**Practical:** Constant, variables and identifiers, logical and relational operators, Programs related to arithmetic operations, arrays and file handling in C. Pattern matching and regular expressions in PERL, Sequence handling in PERL demonstrating string, array and hash. Shell programming - concepts and types of UNIX shell, Linux variables, if statements, control and iteration, arithmetic operations, concepts of awk, grep and sed. Sequence manipulations using shell scripting.

**Biotech. 314 Next Generation Sequencing and Data Analysis 2+1 Sem. II**

Introduction to first, second and third generation sequencing technologies; NGS Terminology; Applications of sequencing technologies. NGS Sequence file formats, data quality evaluation, pre-processing of data: quality control, adapter clipping, quality trimming; de-multiplexing. Bacterial genome assembly; Assessment of genome assembly, Tools for prokaryotic gene prediction (PROKKA); functional annotation (Blast, KEGG, BLAST2GO); domain and motif analysis (PFAM, interpro) Short read mapping tools (BWA, Bowtie); Visualization tools for genome assembly and mapped reads; data submission to SRA.

**Practical:** NGS sequence files format (FASTQ/BED/BAM/GFF), quality control (FastQC), adapter clipping (cutadapt), trimmomatic, Prokaryotic genome assembly (SPADES/soapdenovo), Gene prediction (PROKKA), Functional annotation (Blast/BLAST2GO/PFAM/interpro), Read mapping (BWA/Bowtie), Visualization of mapped reads (IGV/Tablet).

**Biotech. 491 In-house Skill Development in Plant Biotechnology 0+20/**
**Biotech. 492 In-house Skill Development in Bioinformatics 0+20 Sem. I**

B. Tech (Biotech.) students will register for either Biotech. 491 or Biotech. 492 in 7$^{th}$ semester. They will be demonstrated and imparted hands on training on different tissue culture, molecular biology and bioinformatics techniques at School of Agricultural Biotechnology.

**Biotech. 493 Project Formulation, Execution and Presentation 0+10 Sem. II**

The students (2 or 3) will be allotted to each faculty member of School of Agricultural Biotechnology and associated faculty member for Project Formulation, Execution and Presentation.

**Biotech. 494 Entrepreneurial Development in Biotechnology 0+10 Sem. II**

Modules:

I. Micropropagation
II. DNA fingerprinting
III. Genetic purity for maintenance breeding
IV. Marker assisted selection
V. Database Management skills

**PROGRAMME**

**M.Sc. (Biotechnology)**

## DESCRIPTION OF COURSE CONTENTS

**MBB-501 Principles of Biotechnology 3+0 Sem. I**

**Unit I** 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. **Unit II** 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; recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research, Plant transformation: Gene transfer methods and applications of GM crops. **Unit III** 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; Plant cell and tissue culture techniques and their applications. Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics. Plant cell and tissue culture techniques and their applications. **Unit IV** Introduction to Emerging topics: Genome editing, gene silencing, 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.

**MBB-502* Fundamentals of Molecular Biology 3+0 Sem. I**

**Unit I** 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 organization in prokaryotes and eukaryotes; DNA Topology; DNA re-association kinetics, Types of repeat sequences. **Unit II** 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. **Unit III** 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. **Unit IV** 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- and Post-translational modifications of proteins; Translational control; Protein stability -Protein turnover and degradation. **Unit V** Gene regulation in prokaryotes, Constitutive and Inducible expression, small molecule regulators; Operon concept: *lac* and *trp* operons, attenuation, anti-termination, stringent control. 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.

**MBB-503 Molecular Cell Biology 3+0 Sem. I**

**Unit I** Origin of life, History of cell biology, Evolution of the cell: endo-symbiotic theory, tree of life, General 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. **Unit II** Cell wall, cell membrane, structure and composition of bio-membranes, Structure and function of major organelles: Endoplasmic reticulum Ribosomes, Golgi apparatus, Mitochondria, Chloroplasts, Lysosomes, Peroxisomes, Micro-bodies, Vacuoles, Nucleus, Cyto-skeletal elements. **Unit III** 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. **Unit IV** Chromatin structure, Cell division and regulation of cell cycle; Mechanisms of cell division, Molecular 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). **Unit V** Morphogenetic movements and the shaping of the body plan, Cell diversification, cell memory, cell determination, and the concept of positional values; Differentiated cells and the maintenance of tissues and organ development; Stem cells: types and applications; Basics of Animal development in model organisms (C. elegans; Drosophila); Plant development.

**MBB-504* Techniques in Molecular Biology I 0+3 Sem. I**

Good lab practices, preparation of buffers and reagents. Principle of centrifugation and spectrophotometry. Growth of bacterial culture and preparation of growth curve, Isolation of Genomic DNA from bacteria. Isolation of plasmid DNA from bacteria. Growth of lambda phage and isolation of phage DNA. Isolation and restriction of plant DNA (e.g., Rice / Moong / Mango / Merigold). Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry PCR using isolated DNA. PAGE Gel electrophoresis. Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNA construction. Transformation of E. coli and selection of transformants. Chromatographic techniques (a)TLC (b) Gel Filtration Chromatography, (c) Ion exchange Chromatography, (d) Affinity Chromatography. Dot blot analysis, Southern hybridization, Northern hybridization. Western blotting and ELISA. Radiation safety and non-radio isotopic procedure.

**MBB-505 Omics and Systems Biology 2+1 Sem. II**

**Unit I** 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. **Unit II** 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 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. **Unit IV** Introductory systems Biology - The biochemical models, genetic models and systems model ,Molecules to Pathway, Equilibrium binding and cooperatively – Michaelis-Menten Kinetics, Biological oscillators, Genetic oscillators, Quorum Sensing, Cell-cell communication, Drosophila Development , Pathways to Network ,Gene regulation at a single cell level, transcription network, REGULATORY CIRCUITS,

Negative and positive auto-regulation, Alternative Stable States, Bimodal Switches, Network building and analysis.

**Practical:** Isolation of HMW DNA and brief overview of sequencing, Primary information on genome data analysis. BSA Standard curve preparation, Extraction of protein and estimation methods. Quantification of proteins from different plant tissues using spectrophotometry. 2-D Gel Electrophoresis, 2-D Image analysis. Experiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitin system). Demonstration on MALDI-TOF. Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods.

**MBB-506* Plant Genetic Engineering 3+0 Sem. I**

**Unit I** Historical 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, Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence in situ hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions: Electromobility shift assay. **Unit II** 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; Protein purification; His-tag; GST-tag; MBP-tag etc.; Baculovirus vectors system, Plant based vectors, Ti and Ri plasmids as vectors, Yeast vectors, Shuttle vectors. 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 gene expression; Codon optimization for heterologous expression. Introduction of DNA into mammalian cells; Transfection techniques. **Unit III** 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, Site specific mutagenesis, in molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay. **Unit IV** Genetic transformation of plants: DNA delivery – Agrobacterium mediated method. Direct DNA delivery – chemical mediated electroporation and particle bombardment. Vectors and transgene design - Promoters and Marker genes. Chloroplast transformation. 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.

**MBB-507 Techniques in Molecular Biology II 0+3 Sem. II**

Construction of gene libraries (cDNA and Genomics). Synthesis and cloning of cDNA. Real time PCR and interpretation of data. Molecular markers (i) RAPD. (ii) SSR. (iii) AFLP / ISSR and their analysis. Case study of SSR markers - construction of linkage map. QTL analysis using genotypic data based on SSR. SNP identification and analysis. Proteomics (i) 2D gels, (ii) Mass spectrometry. RNAi - designing of construct, phenotyping of the plant. Yeast 1 and 2-hybrid interaction. Generation and screening of mutants. Transposon mediated mutagenesis. Immunology and molecular diagnostics: Ouchterlony double diffusion, Immunoprecipitation, Radiation Immunodiffusion, Immunoelectrophoretic, Rocket Immunoelectrophoretic, Counter Current Immunoelectrophoretic, ELISA, Latex Agglutination, Immunohistochemistry.

**MBB-508* Introduction to Bioinformatics 2+1 Sem. I**

**Unit I** Bioinformatics basics, scope and importance of bioinformatics; Biological databases for DNA and Protein sequences -PIR, SWISSPROT, GenBank, DDBJ, secondary database: PFAM, PROSITE, structural databases –PDB, SCOP and CATH, Specialized genomic resources, SRA database. **Unit II** Bioinformatics Tools Facilitate the Genome-Wide Identification of Protein-Coding Genes, Sequence analysis, Sequence submission and

retrieval system-SEQUIN, BANKit, 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. **Unit III** Sequencing of protein; Protein secondary structure prediction- Chousfasman, GOR Method, Protein 3DStructure Prediction: Homology Modeling and Ab-inito method; Evaluation of models- Structure validation and refinement - Ramachandran plot, SAVES. Protein function prediction- sequence and domain based, SSR marker identification and Primer designing- principles and methods. Drug discovery, Structure Based Drug Design- Rationale for computer aided drug designing, basic principles, docking, Structure visualization tools: rasmol, chimera.

**Practical:** Usage of NCBI resources Retrieval of sequence/structure from databases and submission. Different Databases, BLAST exercises. Gene/ORF prediction software; Assembly of DNA and RNA Seq data. Annotation of assembled sequences, Phylogenetics and alignment. Visualization of structures, Docking of ligand receptors. Protein structure analysis and modeling.

**MBB-509* Plant Tissue Culture 2+1 Sem. I**

**Unit I** 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; National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods – PCR, ELISA. **Unit II** Micropropagation of field and ornamental crops; Virus elimination by meristem culture, meristem tip culture and micrografting; Virus indexing in tissue culture plants (Using PCR and ELISA); 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; Wide hybridization - embryo culture and embryo rescue techniques; Ovule, ovary culture and endosperm culture. **Unit III** Large-scale cell suspension culture - Production of alkaloids and other secondary metabolites- techniques to enhance secondary metabolite production, Somaclonal and gametoclonal variations – causes and applications; Callus culture and in vitro screening for stress tolerance; Artificial seeds, In vitro germplasm storage andcryo-preservation. Commercial Tissue Culture: Case studies and success stories, Market assessment; project planning and preparation, economics, government policies.

**Practical:** Preparation of stocks- macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium. Micro-propagation of plants by nodal and shoot tip culture. Embryo culture to overcome incompatibility, Anther culture for haploid production. Callus induction in rice, regeneration of shoots, root induction, role of hormones in morphogenesis. Acclimatization of tissue culture plants and establishment in greenhouse. Plan of a commercial tissue culture unit.

**MBB-510 Microbial/ Industrial Biotechnology 2+1 Sem. II**

**Unit I** Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms. **Unit II** Primary metabolites, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics as case study; Recombinant DNA technologies for microbial processes; Strategies for development of industrial microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry. **Unit III** Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio-transformations, Bioreactors, their design and types; Immobilized enzymes-based bioreactors; Microencapsulation technologies for immobilization of microbial enzymes. **Unit IV** Environmental Biotechnology, biotreatment for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bio- remediation of soil; Production of eco-friendly agricultural chemicals, bio-pesticides, bio-herbicides, bio-fertilizers, bio-fuels, etc.

**Practical:** Isolation of industrially important microorganisms, their maintenance and improvement. Lab scale production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery. Study of bio-reactors and their operations. Production of bio-fertilizers. Experiments on microbial fermentation process of antibiotics, bio-pigments, dairy products, harvesting purification and recovery of end products. Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomass estimation. Determination of mass transfer coefficient.

**MBB-511 Molecular Plant Breeding 2+1 Sem. II**

**Unit I** 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 of segregating populations – $F_2$, $F_3$, $BC_1F_1$, $BC_1F_2$, $BC_4F_2$, 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). **Unit II** 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. **Unit III** QTL mapping using structured populations; Association mapping using unstructured populations; Genome Wide Association Studies (GWAS), Principle of Association mapping– GWAS-SNP genotyping methods, 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 Selection, Fine mapping of genes/QTL; Development of gene-based markers; Allele mining by TILLING and Eco-TILLING. **Unit IV** 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 specific traits with examples. Haplotype concept and Haplotype-based breeding; Genetic variability and DNA fingerprinting. Molecular markers in Plant variety protection, IPR issues, hybrid purity testing, clonal fidelity testing and transgenic testing.

**Practical:** Construction of linkage map. QTL analysis using the QTL cartographer and other software. SNP data analysis using TASEEL. Detection of haplotype block using SNP data – pLinksoftware. Genotyping by sequencing methods–Illumina genotyping platform. Marker assisted breeding – MABB case studies quality traits in rice/maize. Genome Assisted Breeding in model crops, Genomic Selection models using the morphological and SNP data.

**MBB-512 IPR, Bio-safety & Bioethics 2+0 Sem. II**

**Unit I** 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 on the commercialization of biotechnology products, ecological implications; Trade agreements- The WTO and other international agreements, and Cross border movement of germplasms. **Unit II** Biosafety and bio-hazards; General principles for the laboratory and environmental bio-safety; Biosafety and risk assessment issues; handling and disposal of bio-hazards; Approved regulatory laboratory practice and principles, The Cartagena Protocol on biosafety; Biosafety regulations in India; national Biosafety Policy and Law; Regulations and Guidelines related to Biosafety in other countries. **Unit III** 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. Monitoring strategies and methods for detecting transgenics. **Unit IV** Field trails – Biosafety research trials – standard operating

procedures, labeling of GM food and crop, Bio-ethics-Mankind and religion, social, spiritual & environmental ethics; Ethics in Biotechnology, labeling of GM food and crop; Biopiracy.

**MBB-513 Immunology and Molecular Diagnostics 3+0 Sem. II**

**Unit I** 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. **Unit II** 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 of Differentiations (CDs),Cytokines-properties, receptors and therapeutic uses. **Unit III** 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. **Unit IV** Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques MBB 513 Immunology and Molecular Diagnostics 3+0 - RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosenor assays for assessing ligand –receptor interaction, CMI techniques-lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, Transgenic mice, Gene knock outs. **Unit V** 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.

**MBB 514 Nano Biotechnology 2+1 Sem. II**

**Unit I** 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.). **Unit II** Cell structure – Bio macromolecules: Types, Structure, Dynamics- Cellular nano machines – cellular transducers, membrane channels, membrane transporters, Membrane motors – Creation of bio-nanostructures. **Unit III** Chemical, physical and biological properties of biomaterials and bio response: biomineralization, structure-property relationships in polymeric materials*;* Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems. **Unit IV** Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

**Practical:** Physical or chemical techniques for the synthesis of metal or metal oxide nanoparticles (a) Synthesis of Zinc Oxide nanoparticle, (b) Synthesis of Nickel metal nanoparticle, (c) Synthesis of Iron Oxide Nanoparticle, (d) Quantum dot preparation. Synthesis and characterization of Carbon Nano-materials (a) Sputtering technique, (b) Purification and characterization of carbon nano materials by microscopy techniques. Biogenic synthesis of Gold/silver nanoparticles. Preparation of thin films of nanomaterials.

**MBB-515 Environmental Biotechnology 3+0 Sem. I**

**Unit I** 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. **Unit II** Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents etc., aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc.,); anaerobic processes: digestion, filtration, etc. **Unit III** 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. **Unit IV** Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

**MBB-516 Bio-entrepreneurship 1+0 Sem. II**

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

**MBB 517 Stress Biology and Genomics 2+0 Sem. I**

**Unit I** 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. **Unit II** 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 stress – effects on physiology and metabolism of plants, SOS pathways and ion homeostasis, Strategies to improve salinity tolerance in plants. 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, biotech Strategies to overcome heavy metal stress Nutrient stress- effects on plant growth and development. Genetic manipulation strategies to overcome the stress effects. **Unit III** Biotic stresses (insects and pathogens): Mode of infection/infestation, physiological effects. Details of host-pathogen interaction and regulatory networks to understand resistance mechanism.

Molecular approaches to counteract biotic stresses.Genomics; transcriptomes, small RNAs and epigenomes; functional genomics; 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. Bioinformatics approaches to determine gene function and network in model plants under stress.

**MBB-518 Gene Regulation 2+0 Sem. I**

**Unit I** Transcriptional regulation – Regulatory proteins, Activators and Repressors, Binding of RNA polymerase, Allosteric regulation, DNA looping, Cooperative binding, Anti-termination, Combinatorial control – Regulation of lac, trpandara Operons. Gene regulation in Lambda phage – lytic or lysogenic establishment. **Unit II** 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 and transcription mechanism. Nuceosome and chromatin assembly. Nucleosomes and their modifiers. Signal integration. Signal transduction and transcriptional regulation. Post-transcriptional gene regulation: Gene Silencing. Epigenetic gene regulation. **Unit III** 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. **Unit IV** Negative auto-regulation, Positive auto-regulation.

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| **MBB-591** | **Master's Seminar** | **1+0** | **Sem. I/II** |
| **MBB-599** | **Master's Research** | **0+30** | **Sem. I/II** |

***CORE COURSES FOR MASTER'S PROGRAMME**

**PROGRAMME**

**Ph. D. (Biotechnology)**

## DESCRIPTION OF COURSE CONTENTS

**MBB-601* Plant Molecular Biology 3+0 Sem. I**

**Unit I** Model Systems in Plant Biology (Arabidopsis, Rice etc.) Forward and Reverse Genetic Approaches. Organization expression and interaction of nuclear, mitochondrial and chloroplast genomes. Cytoplasmic male sterility. **Unit II** Transcriptional and Post-transcriptional Regulation of Gene Expression, Isolation of promoters and other regulatory elements, RNA interference, Transcriptional Gene Silencing, Transcript and Protein Analysis. **Unit III** Plant Developmental Processes, ABC Model of Floral Development, Role of hormones (Ethylene, Cytokinin, Auxin and ABA, SA and JA) in plant development. Regulation of Flowering, Plant photoreceptors and light signal transduction, vernalization, Circadian Rhythms. **Unit IV** Abiotic Stress Responses: Salt, Cold, Heat and Drought. Biotic Stress Responses. Molecular Biology of Plant pathogen Interactions, Molecular Biology of Rhizobium and Agrobacterium- Plant interaction. Role of programmed Cell Death in Development and Defense.

**MBB-602* Plant Genome Engineering 3+0 Sem. II**

**Unit II** Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available molecular marker, transformation and genomic tools for crop improvement. Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc.,) and biotic (insect pests, fungal, viral and bacterial diseases, weeds, etc.,) stresses; Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, mineral nutrients etc.); edible vaccines, etc. **Unit II** Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement; Regulated and tissue-specific expression of transgenes for crop improvement. **Unit III** Gene stacking; Pathway engineering; Marker-free transgenic development strategies; Genome editing: principles and methods, Development of genome edited plants; High throughput phenotyping of transgenic plants. **Unit IV** Field studies with transgenic crops; Environmental issues associated with transgenic crops; Food and feed safety issues associated with transgenic crops; Risk assessment of transgenic food crops.

**MBB-603 Plant Omics and Molecular Breeding 3+0 Sem. I**

**Unit I** Complex traits and genetic architecture, Mapping genes and QTLs, statistical concepts in QTL mapping, highthroughput genotyping using automated platforms, genetic and physical mapping of genomes, study of population structure and kinship, association genetic analysis of QTL, case studies on QTL mapping using different approaches, map-based of cloning genes and QTLs – case studies. **Unit II** Marker assisted breeding (MAB): Principles and methods, marker assisted foreground and background selection, marker assisted recurrent selection, whole genome selection, case studies in MAS, requirement for successful marker assisted breeding, cost of MAB. **Unit III** Concepts and methods of next generation sequencing (NGS), assembly and annotation of NGS data, genome resequencing, DNA sequence comparison, annotation and gene prediction. Genome-wide insertion mutagenesis and its use in functional genomics, transcriptome profiling using microarrays and deep sequencing, study of methylome and its significance, proteome analysis using mass spectrometry, crystallography and NMR, analysis of proteome data, study of protein- protein interactions. **Unit IV** Study of the metabolome, 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), correlating the data from genome, transcriptome, proteome, metabolome and ionome with phenome.

**MBB-604 Commercial Plant Tissue Culture 2+0 Sem. I**

**Unit I** Micro-propagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing. **Unit II** Production of useful compounds via biotransformation and secondary metabolite production: suspension cultures, immobilization, examples of chemicals being produced for use in pharmacy, medicine and industry. **Unit III** Value-addition by transformation; development, production and release of transgenic plants; patent, bio-safety, regulatory, environmental and ethical issues; management and commercialization. **Unit IV** Project planning and preparation, economics (entrepreneurship, cost profit ratio), government policies (incubators, different facilitation projects, loan opportunities). Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/industries.

**MBB-605 Plant Microbe Interaction 2+0 Sem. II**

**Unit I** Microbial communities in the soil and atmosphere, Community dynamics and population interactions with particular reference to plant–microbe and microbe-microbe interactions leading to symbiotic, associative, endophytic and pathogenic interactions, effects of microorganisms on plants, effects of plants on microorganisms. Recognition processes and signal exchange, Molecular aspects of Plant Growth Promoting Rhizobacteria (PGPR), Symbiotic diazotrophs: Rhizobia and association with legumes. Mycorrhizal associations: Ectomycorrhizae, Endomycorrhizae with particular emphasis to AM fungi, Ectendomycorrhizae. Biocontrol agents and their action, endophytes associations. **Unit II** Enzymes, toxins, pili, siderophores, secretion systems of microbes and plants determining soil health, nutrient availability and uptake defense responses in plants: pamp-triggered immunity, effector-triggered susceptibility, qualitative resistance, r genes, structure and function, effector-triggered immunity, regulation of plant cell death, plant hormones in immunity, Plant parasite interactions and its molecular basis and impact on plant functions including photosynthesis, respiration, nitrogen metabolism and translocation. **Unit III** Quorum sensing in bacteria, understanding microbiome, phytobiomes, dynamics, Applied and ecological aspects of symbioses and pathogen defense, techniques to study plant microbe interaction including microbe tagging, metagenomics and use of organismal databases to identify genes involved in interactions. Industrial application of agriculturally important microbes. **Unit IV** Resistance mechanisms against attack by plant pathogens, gene-for-gene interactions; induced resistance; non-host resistance. Systemic Acquired Resistance (SAR) and Induced Systemic Resistance (ISR), Plant and microbial gene expression and signal exchange, specific regulators for different interactions including transgenic plants. Recognition mechanism and signal transduction during plant - pathogen interaction.

**MBB-606 RNA Biology 1+0 Sem. II**

**Unit I** RNA structure, functional evolution: RNA structure, types of RNA and function; Genome evolution- RNA as genetic material to regulatory molecule, Non-Coding RNAs, structure, function and regulation. **Unit II** RNA synthesis, processing and regulation: transcription and its regulation in prokaryotes and eukaryotes; RNA splicing, alternate splicing and RNA editing; Translation and its regulation in prokaryotes and eukaryotes. **Unit III** Genome regulation: Prokaryotic- attenuation, ribozymes, aptamers, riboswitches, CRISPER-Cas; eukaryotic-Exon skipping, nonsense-mediated decay, RNAi, Long non-coding RNA. **Unit IV** Epigenetic regulation. RNA-based gene silencing technologies and their applications for crop improvement.

**MBB-607 Plant Hormones and Signaling 2+0 Sem. I**

**Unit I** Hormone Biosynthesis, Metabolism and its Regulation: Auxin biosynthesis and metabolism, Gibberellin biosynthesis and Inactivation, Cytokinin biosynthesis and metabolism, Ethylene biosynthesis, Abscisic acid biosynthesis and metabolism,

Brassinosteroid biosynthesis and metabolism. Salicylic acid and jasmonate biosynthesis and metabolism. **Unit II** Functioning of hormones in plant growth and development: Transport of Auxins, Induction of vascular tissues by Auxin, Hormones and the regulation of water balance, seed development and germination, Hormonal control of daylength and senescence. **Unit III** Action of Hormones: Hormones in defense against insects and disease; Role of jasmonates, salicylic acids and peptide hormones for defense, growth, development and reproduction; Methods of plant hormone analysis. NPR 1 dependent Salicylic acid signaling, PAMP and effector triggered immunity, systemic acquired resistance and SA signaling. **Unit IV** Hormone Signal Transduction: Auxin metabolism, transport and signal transduction, Cytokinin types, synthesis, metabolism, transport and signal transduction, Gibberellin biosynthesis, transport, signal transduction in stem elongation & Leaf Growth, Ethylene metabolism, perception and signaling in seedling growth and development, Ethylene signal transduction in fruits and flowers, Abscisic acid metabolism, transport and signal transduction in nuclear gene expression and stomatal responses. Brassinosteroid biosynthesis, catabolism and signal transduction. Strigalactone biosynthesis, transport and signaling in plant parasitism and symbiosis. Methods of Plant Hormone Analysis: Quantitative analysis of plant hormones based on LC/MS.

**MBB-608 Computational and Statistical Tools in Biotechnology 2+1 Sem. II**

**Unit I** Basic molecular biology; introduction to the basic principles of structure/function analysis of biological molecules; genome analysis; different types and classification of genome databases (e.g. HTGS, DNA, Protein, EST, STS, SNPs, Unigenes, Ensembl etc. **Unit II** Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack- knifing; Markov Models. Hidden Markov Models, Bayesian estimation and Gibbs sampling. **Unit III** DNA sequence retrieval system, various DNA and protein sequence file formats, DNA sequence analysis, different gene prediction models and gene annotation tools. **Unit IV** Protein sequence analysis and structure prediction, comparative genome analysis, phylogenetic analysis, gene expression analysis tools, programming languages and their applications in bioinformatics.

**Practical:** Different types of databases and database search and retrieval, DNA and protein sequence analysis, Similarity searching and multiple alignments, Gene annotation, Phylogenetic analysis, Sequence analysis, Protein structure prediction, Analysis of microarray data, Programming languages in bioinformatics.

**MBB-610 Genome Editing in Plants 2+0 Sem. II**

**Unit I** Changing phase of plant breeding: from classical to targeted breeding. Molecular basis of recombination and DNA repair. Restriction enzymes: types and its importance. **Unit II** Early history of specific gene modifications. Origin of targeted breeding: Zinc finger and ZFN, TALEs and TALENs, use in targeted modifications. Discovery of CRISPR/Cas as a defense tool in bacteria. Types of CRISPR/Cas system in bacteria. **Unit III** Designing CRISPR/Cas9 system for targeted breeding. Advances in CRISPR/Cas system for targeted genetic changes: nickases, Cas12a, Cas12b, Base editors, prime editors. Practical considerations in genome editing: target identification, designing gRNA, construct design, stage selection, construct delivery methods, mutant identification strategies. Multiplex genome editing. Transgene free methods in genome editing. CRISPR-ACT: CRISPR mediated gene activation and deactivation. Epigenome editing and its potentials. **Unit IV** Recent advances in genome editing. Applications of genome editing. Biosafety and regulatory considerations. Important case studies. Potential of gene editing for nutritional security, natural resource conservation and climate resilience.

**MBB-691 Seminar 1+0 Sem. I/II**

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| **MBB-692** | **Seminar** | **1+0** | **Sem. I/II** |
| **MBB-699** | **Doctoral Research** | **0+75** | **Sem. I/II** |

***CORE COURSES FOR DOCTORAL PROGRAMME**