Course Title: Principles of Biotechnology
Course Code: MBB-501
Course Credit:3(3+0)

OBJECTIVES:

- To understand the basics of Molecular biology, plant and microbial Biotechnology
- Importance and applications in agriculture, case studies and success stories
- Public education, perception, IPR and related issues

UNIT I (12L)

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.

UNIT II (16L)

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, Plant transformation: Gene transfer methods and applications of GM crops.

UNIT III (8L)

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 (12L)

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.

Course Title: Fundamentals of Molecular Biology

Course Code: MBB 502

Course Credit: 3(3+0)

OBJECTIVES:

- To understand the basics of DNA, RNA, structure, types and chromatin assembly.
- To get insights into the Central Dogma, basic cellular processes, role of mutation and recombination.
- To understand different levels of gene regulation and the pathways involved.

THEORY:

Unit I (8L)

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(10)

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 (8)**

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 (10 L)

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 (12 L)

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

Course Title: Molecular Cell Biology
Course Code: MBB 503
Course Credit:3(3+0)

OBJECTIVES:

- To understand the basics structure and function of plant and animal cell
- To get insights into the basic cellular processes, transport, signalling, cell movement, cell division and general regulation mechanisms.

THEORY:

Unit I (8)

Origin of life, History of cell biology, Evolution of the cell: endo-symbiotic theory, treeof life, General structure and differences between prokaryotic and eukaryotic cell;Similarities and distinction between plant and animal cells; different kinds of cells inplant and animal tissues.

Unit II (8)

Cell wall, cell membrane, structure and composition of bio-membranes, Structureand function of major organelles: Endoplasmic reticulum Ribosomes, Golgi apparatus, Mitochondria, Chloroplasts, Lysosomes, Peroxisomes, Micro-bodies, Vacuoles, Nucleus, Cyto-skeletal elements.

Unit III (12)

Membrane transport; Diffusion, osmosis, ionchannels, active transport, mechanism of protein sorting and regulation ofintracellular transport, transmembrane and vesicular transport - endocytosis andexocytosis; General principles of cell communication: hormones and their receptors,signaling through G-protein coupled receptors, enzyme linkedreceptors; signal transduction mechanisms and regulation, Cell junctions, Cell adhesion, Cell movement; Extracellular matrix.

Unit IV (10)

Chromatin structure, Cell division and regulation of cell cycle; Mechanisms of cell division, Molecular eventsat 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 cancerdevelopment - Programmed cell death (Apoptosis).

Unit V (10)

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

Course Title: Techniques in Molecular Biology I
Course Code: MBB 504
Course Code: 3(0+3)

OBJECTIVES:

- To get a basic overview of molecular biology techniques, good lab practices and recombinant DNA technology
- To get a hands on training in chromatography, protein analysis, nucleic acid analysis, bacterial and phage genetics

Topics for conduction wet lab exercises:

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

Course Title: Plant Genetic Engineering
Course Code: MBB 506
Course Credit: 3(3+0)

OBJECTIVES:

- To get a basic overview of molecular cloning, vectors and genomic library construction.
- To get an overview of PCR and its applications, sequencing, gene knockouts, transgenics etc.

Unit1 (10L)

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 (14L)

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 (12L)

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 (12L)

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.

Course Title: Omics and Systems Biology
Course Code: MBB 505
Course Credit: 3(2+1)

OBJECTIVES:

- To get a basic overview of genomics, proteomics, ionomics and metabolomics
- To get a primary information on the application of omics science across the industry

Unit-I (8)

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 (6)

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-1II (6)

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 (6)

Introductory systems Biology - The biochemical models, genetic models and systems model ,Molecules to Pathway, Equilibrium binding and cooperatively – Michaelis-MentenKinetics,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 (12 P):

1. Isolation of HMW DNA and brief overview of sequencing, Primary information on genome data analysis.

2. BSA Standard curve preparation, Extraction of protein and estimation methods. 3.Quantification of proteins from different plant tissues using spectrophotometry. 4.2-D Gel Electrophoresis, 2-D Image analysis.

1. Experiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitin system).

6.Demonstration on MALDI-TOF.

7.Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods.

Course Title: Introduction to Bioinformatics
Course Code: MBB 508
Course Credit: 3(2+1)

OBJECTIVES:

- To get a basic overview of computational techniques related to DNA, RNA and protein analysis.
- To get a hands on training in software's and programs used to analyse, assemble or annotate genomes, phylogenetics, proteomics etc.

THEORY

Unit I (8)

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.

Unit II (10)

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

Unit III (10)

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**,** Structure Based Drug Design- Rationale for computer aided drug designing, basic principles, docking, QSAR.

PRACTICAL (12):

1. Usage of NCBI resources
2. Retrieval of sequence/structure from databases and submission 3.Different Databases, BLAST exercises.
4. Assembly of DNA and RNA Seq data
5. Annotation of assembled sequences, Phylogenetics and alignment

6. Visualization of structures, Docking of ligand receptors

7.Protein structure analysis and modeling

Course Title: Plant Tissue culture
Course Code: MBB 509
Course Credit: 3(2+1)

OBJECTIVES:

- To provide insight into principles of plant cell culture and genetic transformation.
- To get a hands on training in basic plant tissue culture techniques, callusing, micropropagation and analysis.

THEORY

Unit I (12)

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 planttissueculture;National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods – PCR, ELISA

Unit II (12)

Micropropagation of field and ornamental crops; Virus elimination by meristem culture, meristemtip 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; ,Wide hybridization - embryo culture and embryo rescuetechniques; Ovule, ovary culture and endosperm culture.

Unit III (12)

Large-scalecell suspension culture - Production of alkaloids and other secondary metabolites-techniques to enhance secondary metabolite production,Somaclonalandgametoclonal 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 (12)

1. Preparation of stocks - macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium.
2. Micro-propagation of plants by nodal and shoot tip culture.
3. Embryo culture to overcome incompatibility, Anther culture for haploid production.
4. Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis.
5. Acclimatization of tissue culture plants and establishment in greenhouse.
6. Virus indexing in tissue culture

plants. (Using PCR and ELISA).

7. Plan of a commercial tissue culture unit.