M.Sc. (Molecular Biology & Biotechnology) (AY 2023-24)

Semester wise course details:

Semester – I				
Sl. No.	**Course No.**	**Course Title**	**Credit Hours**	**Faculty**
1	**MBB 501**	Principles of Biotechnology	3+0	**Dr Thamilarasi K (NISA)** Dr Kishor U Tribhuvan (IIAB) Dr Shruti Sinha (NISA)
2	**MBB 502***	Fundamentals of Molecular Biology	3+0	**Dr Kishor U Tribhuvan (IIAB)** Dr Binay Kumar Singh (IIAB) Dr Thamilarasi K (NISA) Dr Madan Kumar (IIAB) Dr Shruti Sinha (NISA)
3	**MBB 504***	Techniques in Molecular Biology I	0+3	**Dr Shambhu Krishan Lal (IIAB)** Dr Binay Kumar Singh (IIAB) Dr Sujit Kumar Bishi (IIAB)
4	**MBB 509**	Plant Tissue Culture	2+1	**Dr Shruit Sinha (NISA)** Dr Vijai Pal Bhadana (IIAB) Dr Shambhu Krishan Lal (IIAB)
5	**MBB 518**	Gene Regulation	2+0	**Dr Binay Kumar Singh (IIAB)** Dr Sujay Rakshit (IIAB) Dr Thamilarasi K (NISA)
Semester – II				
Sl. No.	**Course No.**	**Course Title**	**Credit Hours**	**Faculty**
1	**MBB 503***	Molecular Cell Biology	3+0	**Dr Binay Kumar Singh (IIAB)** Dr Sujit Kumar Bishi (IIAB) Dr Madan Kumar (IIAB) Dr Shruti Sinha (NISA)
2	**MBB 505***	Omics and Systems Biology	2+1	**Dr Kishor U Tribhuvan (IIAB)** Dr Biplab Sarkar (IIAB) Dr Soumen Naskar (IIAB) Dr Arnab R Choudhary (NISA)
3	**MBB 511**	Molecular Plant Breeding	2+1	**Dr Avinash Pandey (IIAB)** Dr Vijai Pal Bhadana (IIAB) Dr Sudhir Kumar (IIAB)
4	**MBB 512**	IPR, Biosafety, and Bioethics	2+0	**Dr Avinash Pandey (IIAB)** Dr Sudhir Kumar (IIAB)
5	**MBB 591**	Seminar	0+1	**Dr Binay Kumar Singh (IIAB)** Dr Kishor U Tribhuvan (IIAB) Dr Shambhu Krishan Lal (IIAB) Dr Thamilarasi K (NISA) Dr Sujay Rakshit (IIAB)

Note: ***indicates the core course; Name in bold letter will be course leader***

Course Contents
M.Sc. in Molecular Biology and Biotechnology

I. Course Title : Principles of Biotechnology
II. Course Code : MBB 501
III. Credit Hours : 3+0

IV. Aim of the course

- 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

V. Theory

Unit I (12 Lectures)

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 (16 Lectures)

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 (8 Lectures)

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 (12 Lectures)

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.

VI. Suggested Reading

- Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R. 2014. *Molecular Biology of the Gene*, 7th edition, Cold Spring Harbor Laboratory Press, New York
- Brown T A. 2010. *Gene Cloning and DNA analysis an Introduction* 6th edition, Wiley Blackwell
- Primrose SB and Twyman R. 2006. *Principles of gene Manipulation* 7th edition, Wiley Blackwell

• Singh BD. 2012. *Biotechnology: Expanding Horizons* 4th edition, Kalyani publisher, New Delhi, India

I. Course Title : Fundamentals of Molecular Biology

II. Course Code : MBB 502

III. Credit Hours : 3+0

IV. Aim of the course

- 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.

V. Theory

Unit I (8 Lectures)

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 andTypes of RNA Genome organization in prokaryotes and eukaryotes; DNA Topology; DNA re-association kinetics, Types of repeat sequences.

Unit II (10 Lectures)

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 Lectures)

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 Lectures)

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 Lectures)

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

VI. Suggested Reading

- Nelson DL and Cox M.M. 2017. *Lehinger's Principles of Biochemistry*, 7th edition, W H Freeman Publication New York.
- Krebs, J.E., Goldstein, E.S., Kilpatrick, S.T. 2017. *Lewin's Genes* XII 12th edition, Jones & Bartlett Learning publisher, Inc.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M and Losick R. 2014. *Molecular Biology of the Gene*, 7th edition, Cold Spring Harbor Laboratory Press, New York.
- Alberts, B. 2017. *Molecular Biology of the Cell* 5th edition, WW Norton & Co, Inc.
- Allison, L.A. 2011. *Fundamentals of Molecular Biology*. 2nd Edition, John Wiley and Sons.

I. Course Title : Molecular Cell Biology

II. Course Code : MBB 503

III. Credit Hours : 3+0

IV. Aim of the course

- 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.

V. Theory

Unit I (8 Lectures)

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 Lectures)

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 (12 Lectures)

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 (10 Lectures)

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 cancer development - Programmed cell death (Apoptosis).

Unit V (10 Lectures)

Morphogenetic movements and the shaping of the body plan, Cell diversification, cellmemory, 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.

VI. Suggested Reading

- Alberts, B. 2017. *Molecular Biology of the Cell* 5th edition, WW Norton & Co, Inc.
- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin, K.C., 2016. *Molecular Cell Biology* 8th Edition. W.H. Freeman & Co. New York.
- Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Hopkin, K., Johnson, A., Walter, P., 2013 *Essential of Cell Biology*, WW Norton & Co, Inc.
- Cooper, G.M. and Hausman, R.E. 2013. *The cell: A Molecular Approach* 6th edition, Sinauer Associates, Inc.

I. Course Title : Techniques in Molecular Biology I

II. Course Code : MBB 504

III. Credit Hours : 0+3

IV. Aim of the course

- 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

V. Practicals

- 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.
- PAGEGel 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.

VI. Suggested Reading

- Sambrook, J., and Russell, R.W. 2001. *Molecular Cloning: A Laboratory Manual* 3rd Edition, Cold spring harbor laboratory press, New York.
- Wilson, K., and Walker, J., 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th edition, Cambridge University Press.
- Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA and Struhl K. 2002. *Short Protocols in Molecular Biology* 5th edition, Current Protocols publication.

I. Course Title : Omics and Systems Biology

II. Course Code : MBB 505

III. Credit Hours : 2+1

IV. Aim of the course

- 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

V. Theory

Unit I (8 Lectures)

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 Lectures)

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 (6 Lectures)

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 Lectures)

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

VI. Practical (12)

- 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.

VII. Suggested Reading

- Primrose, S.B. and Twyman, R. 2006. *Principles of Gene Manipulation* 7th edition, Wiley Blackwell
- Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th Edition, Cambridge University Press.

I. Course Title : Plant Genetic Engineering

II. Course Code : MBB 506

III. Credit Hours : 3+0

IV. Aim of the course

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

V. Theory

Unit I (10 Lectures)

Historical background, Restriction Enzymes; DNA Modifying enzymes, ligase, T4 DNA polymerase, Polynucleotide kinaseetc, 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 (14 Lectures)

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 (12 Lectures)

Principles of PCR, Primer design,DNApolymerases, 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 (12 Lectures)

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.

VI. Suggested Reading

- Brown, T.A. 2010. *Gene Cloning and DNA Analysis an Introduction*. 6th edition, Wiley Blackwel.
- Primrose, S.B. and Twyman, R. 2006. *Principles of Gene Manipulation* 7th edition, Wiley Blackwell.
- Sambrook, J., and Russell, R.W. 2001. *Molecular cloning: A laboratory manual* 3rd Edition, Cold spring harbor laboratory press, New York.
- Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th Edition, Cambridge University Press.

I. Course Title : Techniques in Molecular Biology II

II. Course Code : MBB 507

III. Credit Hours : 0+3

IV. Aim of the course

- To get a basic overview of molecular biology techniques, good lab practices and molecular markers.
- To get a hands on training in RNAi, microarrays, yeast2 hybrid and immunological techniques.

V. Practicals

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.
- Microarray studies and use of relevant software.
- 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.

VI. Suggested Reading

- Wilson, K., and Walker, J. 2018. *Principles and Techniques of Biochemistry and Molecular Biology* 8th Edition, Cambridge University Press
- Bonifacino, J. S., Dasso, M., Harford, J. B., Liipincott-Schwartz, J., and Yamada, K. M. 2004. *ShortProtocols in Cell Biology*. John Wiley & Sons, New Jersey

- Hawes, C., and Satiat-Jeunemaitre, B. 2001. *Plant Cell Biology: Practical Approach*. Oxford University Press, Oxford
- Sawhney, S.K., Singh, R. 2014. *Introductory Practical Biochemistry*, Alpha science international limited

I. Course Title : Introduction to Bioinformatics

II. Course Code : MBB 508

III. Credit Hours : 2+1

IV. Aim of the course

- 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.

V. Theory

Unit I (8 Lectures)

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 Lectures)

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 Lectures)

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.

VI. Practical (12 Lectures)

- Usage of NCBI resources
- Retrieval of sequence/structure from databases and submission
- Different Databases, BLAST exercises.
- 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

VII. Suggested Reading

- Attwood, T.K., and Parry-Smith, D. J. 2004. *Introduction to Bioinformatics*, Pearson Education (Singapore) Pvt. Ltd.
- David Edwards (Ed.) 2007. *Plant Bioinformatics: Methods and Protocols*. Humana Press, New Jersey, USA.

- Mount, D.W. 2004. *Bioinformatics: Sequence and Genome Analysis.* 2nd Revised edition Cold Spring Harbor Laboratory Press, U.S.
- Pevsner J. 2009. *Bioinformatics and Functional Genomics*, 2nd edition, Wiley-Blackwell.

I. Course Title : Plant Tissue Culture

II. Course Code : MBB 509

III. Credit Hours : 2+1

IV. Aim of the course

- 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.

V. Theory

Unit I (12 Lectures)

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 Lectures)

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 Lectures)

Large-scalecell 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 and cryo-preservation. Commercial Tissue Culture: Case studies and success stories, Market assessment; project planning and preparation, economics, government policies

VI. Practical (12)

- 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 tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis.
- Acclimatization of tissue culture plants and establishment in greenhouse.
- Virus indexing in tissue culture plants. (Using PCR and ELISA).
- Plan of a commercial tissue culture unit.

VII. Suggested Reading

- Razdan, M.K. 2003. *Introduction to plant tissue culture*, 2nd edition, Oxford publications group
- Butenko, R.G. 2000. *Plant Cell Culture* University Press of Pacific
- Herman, E.B. 2008. *Media and Techniques for Growth, Regeneration and Storage*, Agritech Publications, New York, USA.
- Bhojwani, S.S and Dantu P. 2013. *Plant Tissue Culture – An Introductory Text*. Springer Publications.
- Gamborg, O.L and G.C. Philips (eds.). 2013. *Plant Cell, Tissue and Organ culture-Lab Manual*. Springer Science & Business media.

I. Course Title : Microbial/ Industrial Biotechnology

II. Course Code : MBB 510

III. Credit Hours : 2-+1

IV. Aim of the course

To familiarize about the various microbialprocesses/systems/activities, which have been used for the development of industrially important products/processes.

V. Theory

Unit (8 Lectures)

Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms.

Unit II (8 Lectures)

Primary metabolites, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non-ribosomal peptide 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 (8 Lectures)

Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio-transformations, 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.

Unit IV (8 Lectures)

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.

VI. 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 processofantibiotics, bio-pigments, dairy products,

harvesting purification and recovery of end products.
- Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomassestimation.
- Determination of mass transfer coefficient.

VII. Suggested Reading

- Waites, M.J., Morgan, N.L., Rockey, J.S., Higton, G. 2001. *Industrial Microbiology: An Introduction*, Wiley-Blackwell.
- Slater, A., Scott, N.W., & Fowler, M.R. 2003. *The Genetic Manipulation of Plants. Plant Biotechnology Oxford, England: Oxford University Press*.
- Kun, L.Y. (Ed.). 2003. *Microbial biotechnology: principles and applications*. World Scientific Publishing Company.

I. Course Title : Molecular Plant Breeding

II. Course Code : MBB 511

III. Credit Hours : 2-+1

IV. Aim of the course

- To familiarize the students about the use of molecular biology tools in plant breeding.
- To provide a hands on training in data analysis, diversity analysis and mapping of genes and QTLs.

V. Theory

Unit I (8 Lectures)

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 (8 Lectures)

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, F_2, F_3, BC_1F_1, RIL. Construction of genetic map, Mapping genes for qualitative traits; Genotyping by sequencing and high-density chip arrays.

Unit III (8 Lectures)

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 (8 Lectures)

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.

VI. 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 usingthe morphological and SNP data

VII. Suggested Reading

- Acquaah, G. 2007. *Principles of Plant Genetics and Breeding*, Blackwell Publishing Ltd. USA.
- Weising, K., Nybom, H., Wolff, K., and Kahl, G. 2005. *DNA Fingerprinting in Plants: Principles, Methods and Applications*, 2nd ed. Taylor and Francis Group, Boca Raton, FL.
- Halford, N. 2006. *Plant Biotechnology-Current and future applications of genetically modified crops*, John Wiley and Sons, England.
- Singh, B. D. and Singh, A. K. 2015. *Marker-Assisted Plant Breeding: Principles and Practices* Springer (India) Pvt. Ltd.

5. Boopathi, NM. 2013. *Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits*. Springer India. p293.

I. Course Title : IPR, Bio-safety & Bioethics

II. Course Code : MBB 512

III. Credit Hours : 2+0

IV. Aim of the course

- To familiarize the students about ethical and biosafety issues in plant biotechnology.
- To provide a hands-on training in data analysis, diversity analysis and mapping of genes and QTLs.

V. Theory

Unit I (10 Lectures)

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 (8 Lectures)

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 (8 Lectures)

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 (6 Lectures)

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

VI. Suggested Reading

- Goel, D. and Parashar, S. 2013. *IPR, biosafety, and bioethics*.
- Joshi, R. 2006. *Biosafety and Bioethics*.
- Nambisan, P. 2017. *An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology*.

I. Course Title : Immunology and Molecular Diagnostics

II. Course Code : MBB 513

III. Credit Hours : 3+0

IV. Theory

Unit I (6 Lectures)

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 (12 Lectures)

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 (8 Lectures)

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 (10 Lectures)

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques – 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 (12 Lectures)

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.

V. Suggested Reading

- Owen J.A., Punt, J., & Stranford, S. A. 2013. *Kuby immunology* (p. 692). New York: WH Freeman.
- Kenneth, M., and Weaver, C. 2017. *Janeways Immunobiology*, 9th Edition, New York, USA: Garland Science, Taylor & Francis publisher.
- William, P. 2013. *Fundamental of Immunology*, 7th edition, Lippencott, William and Wilkins publisher.

I. Course Title : Nano Biotechnology

II. Course Code : MBB 514

III. Credit Hours : 2+1

IV. Aim of the course

Understanding the molecular techniques involved in structure and functions of nano-biomolecules in cells such as DNA, RNA and proteins.

V. Theory

Unit I (8 Lectures)

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 (8 Lectures)

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).

Unit III (8 Lectures)

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,

Unit (8 Lectures)

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

VI. Practical

- Isolation of enzymes and nucleic acids involved in biosynthesis of nanomaterials
- Synthesis of Gold/silver Nanoparticles by biogenic methods, Synthesis of micelles and inverse micelles
- Synthesis of Carbon Nano-materials by Chemical Vapor Deposition and Sputtering technique
- Preparation ofthiolate silver nanoparticles, Purification and measurement of carbon nano materials
- Zinc selenide quantum dot preparation, Synthesis of Iron Oxide Nanoparticle
- Thin film preparation by spin coating technique, Synthesis of Nickel metal nanoparticle by urea decomposition method
- Synthesis of Zinc Oxide nanoparticle

VII. Suggested Reading

- Nalwa, H.S. 2005. *Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology*. American Scientific Publications.
- Niemeyer C.M. and Mirkin C.A. (Eds) 2005. *Nanobiotechnology: Concepts Applications and Perspectives,* Wiley Inter-science publications.
- Cao, G., and Wang, Y. 2004. *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, Imperial College Press.

I. Course Title : Environmental Biotechnology

II. Course Code : MBB 515

III. Credit Hours : 3+0

IV. Aim of the course

To apprise the students about the role of biotechnology in environment management for sustainable eco-system and human welfare.

V. Theory

Unit I (8 Lectures)

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 (8 Lectures)

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,detergentsetc; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc); anaerobic processes: digestion, filtration, etc.

Unit III (8 Lectures)

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 (8 Lectures)

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.

VI. Suggested Reading

- Evans, G. M. and Furlong, J. C. 2010. *Environmental Biotechnology: Theory and Application*. 2nd edition, Wiley-Blackwell.
- Jordening HJ and Winter J. 2006. *Environmental Biotechnology: Concepts and Applications*. Wiley-VCH Verlag.

I. Course Title : Bio-entrepreneurship

II. Course Code : MBB 516

III. Credit Hours : 1+0

IV. Aim of the course

The objective of this course is to teach students about fundamentals of entrepreneurship, launching a venture or a start up in biotechnology-based theme.

V. Theory

Unit I (4 Lectures)

Scope in biotechnology; types of bio-industries – bio-pharma, bio-agri, 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-entrepreneurship- entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India)

Unit II (4 Lectures)

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 (4 Lectures)

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 (4 Lectures)

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;

VI. Suggested Reading

- Adams, D.J. and Sparrow, J.C. 2008. *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences*. Bloxham: Scion.
- Shimasaki, C.D. 2014. *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies*. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
- Onetti, A., and Zucchella, A. 2014. *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge*. Routledge.
- Jordan, J. F. 2014. *Innovation, Commercialization, and Start-Ups in Life Sciences*. London: CRC Press.
- Desai, V. 2009. *The Dynamics of Entrepreneurial Development and Management*. New Delhi: Himalaya Pub. House.

I. Course Title : Stress Biology and Genomics

II. Course Code : MBB 517

III. Credit Hours : 2+0

IV. Aim of the course

To provide advanced knowledge on genomics with reference to abiotic stress tolerance and biotic stress resistance in plants tolerance.

V. Theory

Unit I (10 Lectures)

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.

Unit II (12 Lectures)

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. 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, 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 (10 Lectures)

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.

VI. Suggested Reading

- Buchanan, B.B., Gruissem, W. and Jones R. 2015. *Biochemistry and Molecular Biology of Plants*, 2nd edition, Wiley and Blackwell Publications.
- Sarwat, M., Ahmad, A., Abdin, M.Z. 2013. *Stress Signaling in Plants: Genomics and Proteomics Perspective*, Volume 1, Springer.
- Heribert Hirt. 2010. *Plant Stress Biology: From Genomics to Systems Biology*, John Wiley.
- Pandey, G.K. 2015. *Elucidation of Abiotic Stress Signaling in Plants*, Stringer.

I. Course Title : Gene Regulation

II. Course Code : MBB 518

III. Credit Hours : 2+0

IV. Aim of the course

To understand the basics of gene regulation including a wide range of mechanisms that are used by organisms to increase or decrease the production of specific gene products in terms of time, space, conditions or their combinations.

V. Theory

Unit I (8 Lectures)

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.

Unit II (10 Lectures)

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. Signal integration. Signal transduction and transcriptional regulation. Gene Silencing. Epigenetic gene regulation.

Unit III (10 Lectures)

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 (4 Lectures)

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

VI. Suggested Reading

- Nelson, D. L. and Cox, M. M. 2017. *Lehinger's Principles of Biochemistry*, 7th edition, W H Freeman Publication New York
- Krebs, J. E., Goldstein, E. S., Kilpatrick, S. T. 2017. *Lewin's Genes* XII 12th edition, Jones & Bartlett Learning publisher, Inc
- Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine,M., & Lonick, R. 2014. *Molecular Biology of the Gene*, 7th Edition, Cold Spring Harbor Laboratory Press, New York.
- Gardner, E. J., Simmons MJ and Snustad, D.P. 2006. *Principles of Genetics* (2006) eighth Edition. Wiley