MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Course Structure

COURSE NO. COURSE TITLE CREDITS SEM

MBB 501* PRINCIPLES OF BIOTECHNOLOGY 3+0 I
MBB 502*/ ❶
BIOCHEM 504/
BIF 508
FUNDAMENTAL OF MOLECULAR BIOLOGY 3+0 I
MBB 503 MOLECULAR CELL BIOLOGY 3+0 II
MBB 504 PLANT TISSUE CULTURE AND GENETIC
TRANSFORMATION
2+1 II
MBB 505* TECHNIQUES IN MOLECULAR BIOLOGY - I 0+3 I
MBB 506 INDUSTRIAL BIOTECHNOLOGY 2+1 II
MBB 507 MOLECULAR BREEDING 2+0 II
MBB 508/ ❷
BIF 517
GENOMICS & PROTEOMICS 2+1 I
MBB 509 TECHNIQUES IN MOLECULAR BIOLOGY - II 0+3 II
MBB 510 BIOSAFETY, IPR AND BIOETHICS 2+0 I
MBB 511/ ❸
ABT 616
ANIMAL BIOTECHNOLOGY 3+0 I
MBB 512/ ❹
BIOCHEM 506/
BIF 510
IMMUNOLOGY AND MOLECULAR DIAGNOSTICS 2+1 II
MBB 513 NANO-BIOTECHNOLOGY 3+0 I
MBB 514/ ❺
FST 519
FOOD BIOTECHNOLOGY 2+1 I
MBB 515/ ❻
FSC 509
BIOTECHNOLOGY OF HORTICULTURAL CROPS 2+1 II
MBB 553*/ ❼
STAT 534/
FST 531/
SOC 512
BIOSTATISTICS AND COMPUTERS 2+1 I
MBB 555/ ❽
BIF 501/
ABT 608/
FSC 604
INTRODUCTION TO BIOINFORMATICS 2+1 I
MBB 556 ENVIRONMENTAL BIOTECHNOLOGY 3+0 II
MMB 591 MASTER'S SEMINAR 1 I, II
MMB 599 MASTER'S RESEARCH 20 I, II
MBB 601 ADVANCES IN PLANT MOLECULAR BIOLOGY 3+0 I
MBB 602 ADVANCES IN GENETIC ENGINEERING 3+0 I
MBB 603 ADVANCES IN MICROBIAL BIOTECHNOLOGY 3+0 II
MBB 604/ ❻
VSC 604/
FLA 605
ADVANCES IN CROP BIOTECHNOLOGY 3+0 I
MBB 605/ ❾
BIOCHEM 606/
PP 602
ADVANCES IN FUNCTIONAL GENOMICS,
PROTEOMICS AND METABOLOMICS
3+0 II
MBB 606 COMMERCIAL PLANT TISSUE CULTURE 2+0 I
MBB 607/ ❸
ABT 707

ADVANCES IN ANIMAL BIOTECHNOLOGY 2+0 II
MBB 691 DOCTORAL SEMINAR I 1 I, II
MBB 692 DOCTORAL SEMINAR II 1 I, II
471
MMB 699 DOCTORAL RESEARCH 45 I, II

SERVICE COURSE

PSMA 606 BIOTECHNOLOGY IN PLANTATION CROPS AND SPICES
1+1 II
PP 603 MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS (IN PART)
2+1 I

* Compulsory for Master's programme; Compulsory for Doctoral programme - Any two courses of 600 series + Compulsory courses of M. Sc., if not studied earlier

To be taught by: ❶ Bioinformatics, Biochemistry, Molecular Biology & Biotechnology; ❷ Bioinformatics, Molecular Biology & Biotechnology; ❸ Animal Biotechnology; ❹ Veterinary Microbiology; ❺ Molecular Biology & Biotechnology; ❻ Molecular Biology & Biotechnology; ❼ Statistics; ❽ Animal Biotechnology, Bioinformatics, Molecular Biology & Biotechnology; ❾ Biochemistry, Molecular Biology & Biotechnology, Plant Physiology

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MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Course Contnts

MBB 501 PRINCIPLES OF BIOTECHNOLOGY 3+0 SEM - I

ObjectiveT

o familiarize the students with the fundamental principles of Biotechnology, various developments in Biotechnology and its potential applications.

Theory

UNIT-I: History, scope and importance; DNA structure, function and metabolism.
UNIT-II: DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; Gene libraries; PCR amplification; Plant and animal cell and tissue culture techniques and their applications.
UNIT-III: Molecular markers and their applications; DNA sequencing; Applications of gene cloning in basic and applied research; Genetic engineering and transgenics; Introduction to Genomics, transcriptomics and proteomics.
UNIT-IV: General application of biotechnology in Agriculture, Medicine, Animal husbandry, Environmental remediation, Energy production and Forensics; Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Suggested Readings

Becker JM, Coldwell GA & Zachgo EA. 2007. *Biotechnology – a Laboratory Course*. Academic Press.
Brown CM, Campbell I & Priest FG. 2005. *Introduction to Biotechnology*. Panima Publ.
Brown TA. *Gene Cloning and DNA Analysis*. 5th Ed. Blackwell Publ.
Dale JW & von Schantz M. 2002. *From Genes to Genomes: Concepts and Applications of DNA Technology*. John Wiley & Sons.
Gupta PK. 2004. *Biotechnology and Genomics*. Rastogi Publ.
Sambrook J, Fritsch T & Maniatis T. 2001. *Molecular Cloning – a Laboratory Manual*. 2nd Ed. Cold Spring Harbour Laboratory Press.
Singh BD. 2007. *Biotechnology Expanding Horiozon*. Kalyani Publ.

MBB 502/ FUNDAMENTALS OF MOLECULAR BIOLOGY 3+0 SEM - I

BIOCHEM 504/ (To be taught jointly by Molecular Biology & Biotechnology, Biochemistry and **BIF508** Bioinformatics)

ObjectiveT

o familiarize the students with the basic cellular processes at molecular level.

Theory

UNIT-I: Historical developments of molecular biology; nucleic acids as genetic material, chemistry, structure and properties of DNA and RNA.
UNIT-II: Genome organization in prokaryotes and eukaryotes; repetitive and nonrepetitive DNA, satellite DNA; DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase, nucleases and restriction enzymes; site directed mutagenesis, molecular mechanism of mutation, DNA repair mechanisms.
UNIT-III: Ribosomes structure and function, organization of ribosomal proteins and RNA

genes, transcription, RNA editing, RNA processing, etc; Genetic code, aminoacyl tRNA synthases' inhibitors of replication, transcription and translation.
UNIT-IV: Translation and post translational modifications; Regulation of gene expression in prokaryotes and eukaryotes.

Suggested Readings

Lewin B. 2008. *Gene IX*. Peterson Publ. / Panima.
Malacinski GM & Freifelder D. 1998. *Essentials of Molecular Biology*. 3rd Ed. Jones & Bartlett.
Nelson DL & Cox MM. 2007. *Lehninger's Principles of Biochemistry*. W.H. Freeman.
Primrose SB. 2001. *Molecular Biotechnology*. Panima.
Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008.*Molecular Biology of the Gene*. 6th Ed. Pearson Edu.
473

MBB 503 MOLECULAR CELL BIOLOGY 3+0 SEM - II

ObjectiveT
o familiarize the students with the cell biology at molecular level.

Theory

UNIT-I: General structure and constituents of cell; Similarities and distinction between plant and animal cells; Cell wall, cell membrane, structure and composition of biomembranes, cell surface related functions.
UNIT-II: Structure and function of major organelles: Nucleus, Chloroplasts, Mitochondria, Ribosomes, Lysosomes, Peroxisomes, Endoplasmic reticulum, Microbodies, Golgi apparatus, Vacuoles, etc.
UNIT-III: Organellar genomes and their manipulation; Ribosomes in relation to cell growth and division; Cyto-skeletal elements.
UNIT-IV: Cell division and regulation of cell cycle; Membrane transport; Transport of water, ion and biomolecules; Signal transduction mechanisms; Protein targeting.

Suggested Readings

Gupta PK. 2003. *Cell and Molecular Biology*. 2nd Ed. Rastogi Publ.
Lodish H. 2003. *Molecular Cell Biology*. 5th Ed. W.H. Freeman & Co.
Primrose SB. 2001. *Molecular Biotechnology*. Panima.

MBB 504 PLANT TISSUE CULTURE AND GENETIC TRANSFORMATION 2+1 SEM - II

ObjectiveT
o familiarize the students and provide hands on training on various techniques of plant tissue culture, genetic engineering and transformation.

Theory

UNIT-I: History of plant cell and tissue culture; Culture media; Various types of culture; callus, suspension, nurse, root, meristem, etc.; *In vitro* differentiation: organogenesis and somatic embryogenesis; Plant growth regulators: mode of action, effects on *in vitro* culture and regeneration; Molecular basis of plant organ differentiation.
UNIT-II: Micropropagation; Anther and microspore culture; Somaclonal variation; *In vitro* mutagenesis; *In vitro* fertilization; *In vitro* germplasm conservation; Production of secondary metabolites; Synthetic seeds.
UNIT-III: Embryo rescue and wide hybridization; Protoplast culture and regeneration; Somatic hybridization: protoplast fusion, cybrids, asymmetric hybrids, etc.
UNIT-IV: Methods of plant transformation; Vectors for plant transformation; Genetic and molecular analyses of transgenics; Target traits and transgenic crops; Biosafety issues, testing of transgenics, regulatory procedures for commercial approval.

Practical

- Laboratory set-up.
- Preparation of nutrient media; handling and sterilization of plant material; inoculation, subculturing and plant regeneration.
- Anther and pollen culture.
- Embryo rescue.
- Suspension cultures and production of secondary metabolites.
- Protoplast isolation, culture and fusion.
- Gene transfer using different methods, reporter gene expression, selection of transformed tissues/plants, molecular analysis.

Suggested Readings

Bhojwani SS. 1983. *Plant Tissue Culture: Theory and Practice*. Elsevier.
Christou P & Klee H. 2004. *Handbook of Plant Biotechnology*. John Wiley & Sons.
Dixon RA. 2003. *Plant Cell Culture*. IRL Press.

George EF, Hall MA & De Klerk GJ. 2008. *Plant Propagation by Tissue Culture*. Agritech Publ.
Gupta PK. 2004. *Biotechnology and Genomics*. Rastogi Publ.
Herman EB. 2005-08. *Media and Techniques for Growth, Regeneration and Storage*. Agritech Publ.
Pena L. 2004. *Transgenic Plants: Methods and Protocols*. Humana Press.
474
Pierik RLM. 1997. *In vitro Culture of Higher Plants*. Kluwer.
Singh BD. 2007. *Biotechnology: Expanding Horiozon.* Kalyani.

MBB 505 TECHNIQUES IN MOLECULAR BIOLOGY-I 0+3 SEM - I

(Pre-requisite MBB 501)

ObjectiveT

o provide hands-on training on basic molecular biology techniques.

Practical

UNIT-I: Good lab practices; Biochemical techniques: Preparation of buffers and reagents, Principle of centrifugation, Chromatographic techniques (TLC, Gel Filtration Chromatography, Ion exchange Chromatography, Affinity Chromatography).
UNIT-II: Gel electrophoresis- agarose and PAGE (nucleic acids and proteins); Growth of bacterial culture and preparation of growth curve; Isolation of plasmid DNA from bacteria; Growth of lambda phage and isolation of phage DNA; Restriction digestion of plasmid and phage DNA; Isolation of high molecular weight DNA and analysis.
UNIT-III: Gene cloning – Recombinant DNA construction, transformation and selection of transformants; PCR and optimization of factors affecting PCR.
UNIT-IV: Dot blot analysis; Southern hybridization; Northern hybridization; Western blotting and ELISA; Radiation safety and non-radio isotopic procedure.

Suggested Readings

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. *Short Protocols in Molecular Biology*. John Wiley.
Kun LY. 2006. *Microbial Biotechnology*. World Scientific.
Sambrook J, Russel DW & Maniatis T. 2001. *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbour Laboratory Press.

MBB 506 INDUSTRIAL BIOTECHNOLOGY 2+1 SEM - II

ObjectiveT

o familiarize students about microbial processes/systems/activities for the development of industrially important products/ processes.

Theory

UNIT-I: Introduction, scope and historical developments; Isolation, screening and genetic improvement and maintenance of industrially important organisms.
UNIT-II: Types fermentation systems; Bioreactor designs and operations; Production of primary and secondary metabolites e.g alcohol, organic acids, organic solvents, amino acids, enzymes, antibiotics.
UNIT-III: Production of fermented beverages, single cell protein; Recombinant DNA technology based products, Biotransformation.
UNIT-IV*:* Overproduction of metabolites; Metabolic engineering of microbes for production of novel products for industry; Downstream processing; Immobilization of cells/enzymes.
UNIT-V: Industrial biotechnology for pollution control, treatment of industrial and other wastes, Production of eco-friendly chemicals e.g biopesticides, bio-insecticides, biofertilizers, bio-fuels, etc.

Practical

- Isolation of industrially important microorganisms, their maintenance and improvement.
- Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery.
- Study of bio-reactors and their operations.
- Production of biofertilizers.
- Immobilization of cells and enzymes, studies on its kinetic behavior.

Suggested Readings

Cruger W & Cruger A. 2004. *Biotechnology – A Textbook of Industrial Microbiology,* Panima.
Huffnagle GB & Wernick S. 2007. *The Probiotics Revolution: The Definitive Guide to Safe, Natural Health*. Bantam Books.

Kun LY. 2006. *Microbial Biotechnology*. World Scientific.
Primrose SB. 2001. *Molecular Biotechnology*. Panima.

Ward OP. 1989. *Fermentation Biotechnology*, Prentice Hall.

MBB 507 MOLECULAR BREEDING 2+0 SEM - II

ObjectiveT

o familiarize the students about the use of molecular biology tools in plant breeding.

Theory

UNIT-I: Principles of plant breeding; Breeding methods for self and cross pollinated crops; Heterosis breeding; Limitations of conventional breeding; Aspects of molecular breeding.

UNIT-II: Development of sequence based molecular markers - SSRs and SNPs; Advanced methods of genotyping; Mapping genes for qualitative and quantitative traits.

UNIT-III: QTL mapping using structured populations; AB-QTL analysis; Association mapping of QTL; Fine mapping of genes/QTL; Map based gene/QTL isolation and development of gene based markers; Allele mining by TILLING and Eco-TILLING; Use of markers in plant breeding.

UNIT-IV: Marker assisted selection (MAS) in backcross and heterosis breeding; Transgenic breeding; Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples.

Suggested Readings

Chittaranjan K. 2006-07. *Genome Mapping and Molecular Breeding in Plants.* Vols. IVII. Springer.
Newbury HJ. 2003. *Plant Molecular Breeding*. Blackwell Publ.
Weising K, Nybom H, Wolff K & Kahl G. 2005. *DNA Fingerprinting in Plants: Principles, Methods and Applications*. Taylor & Francis.

MBB 508/ GENOMICS AND PROTEOMICS 2+1 SEM - I

BIF 517 (To be taught jointly by Molecular Biology & Biotechnology and Bioinformatics)

ObjectiveT

o familiarize the students about the genomic and proteomic concepts and usage of various algorithms and programmes in analysis of genomic and proteomic data.

Theory

UNIT-I: Genomics: Whole genome analysis and comparative genomics, classical ways of genome analysis, large fragment genomic libraries; Physical mapping of genomes; Genome sequencing, sequence assembly and annotation.

UNIT-II: Functional genomics: Candidate gene identification, DNA chips, Mutants and RNAi, Metabolomics for elucidating metabolic pathways, etc.

UNIT-III: Proteomics - Introduction to basic proteomics technology, Bio-informatics in Proteomics, Gene to Protein Function: a Roundtrip, Proteome analysis.

UNIT-IV: Linkage analysis, genotyping analysis, pharmacogenomics, human/plant genome and science after genomic era; Applications of genomics and proteomics in agriculture, human health and industry.

Practical

- Gene Prediction Tools: GENSCAN, GRAIL, FGENESH
- NCBI Genomic Resources
- Proteomics Tools: EXPASY, CDART

Suggested Readings

Azuaje F & Dopazo J. 2005. *Data Analysis and Visualization in Genomics and Proteomics*. John Wiley & Sons.
Brown TA. 2007. *Genome III*. Garland Science Publ.
Campbell AM & Heyer L. 2004. *Discovery Genomics, Proteomics and Bioinformatics*. Pearson Edu.
Gibson G & Muse SV. 2004. *A Primer of Genome Science*. Sinauer Associates.
Jollès P & Jörnvall H. 2000. *Proteomics in Functional Genomics: Protein Structure Analysis*. Birkhäuser.
Kamp RM. 2004. *Methods in Proteome and Protein Analysis*. Springer.
Primrose SB & Twyman RM. 2007. *Principles of Genome Analysis and Genomics*. Blackwell.
Sensen CW. 2005. *Handbook of Genome Research*. Vols. I, II. Wiley CVH.

MBB 509 TECHNIQUES IN MOLECULAR 0+3 SEM - II
BIOLOGY -II

(Pre-requisite MBB 505)

ObjectiveT
o provide hands-on training on various molecular techniques used in molecular breeding and genomics.

Practical

UNIT-I: Construction of gene libraries; Synthesis and cloning of cDNA and RTPCR analysis; Real time PCR and interpretation of data.
UNIT-II: Molecular markers (RAPD, SSR, AFLP etc) and their analysis; Case study of SSR markers (linkage map, QTL analysis etc); SNP identification and analysis; Microarray studies and use of relevant software.
UNIT-III: Proteomics (2D gels, mass spectrometry, etc.); RNAi (right from designing of construct to the phenotyping of the plant); Yeast 1 and 2-hybrid interaction.
UNIT-IV: Generation and screening of mutants; Transposon mediated mutagenesis.

Suggested Readings

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. *Short Protocols in Molecular Biology*. Wiley.
Caldwell G, Williams SN & Caldwell K. 2006. *Integrated Genomics: A Discovery-Based Laboratory Course*. John Wiley.
Sambrook J, Russel DW & Maniatis T. 2001. *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbour Laboratory Press.

MBB 510 BIOSAFETY, IPR AND BIOETHICS 2+0 SEM - I

ObjectiveT
o discuss about various aspects of biosafety regulations, IPR and bioethic concerns arising from the commercialization of biotech products.

Theory

UNIT-I: Biosafety and risk assessment issues; Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety, Cross border movement of germplasm; Risk management issues - containment.
UNIT-II: General principles for the laboratory and environmental biosafety; Health aspects; toxicology, allergenicity, antibiotic resistance, etc; Impact on environment: gene flow in natural and artificial ecologies; Sources of gene escape, tolerance of target organisms, creation of superweeds/superviruses, etc.
UNIT-III: Ecological aspects of GMOs and impact on biodiversity; Monitoring strategies and methods for detecting transgenics; Radiation safety and nonradio isotopic procedure; Benefits of transgenics to human health, society and the environment.
UNIT-IV: The WTO and other international agreements; Intellectual properties, copyrights, trademarks, trade secrets, patents, geographical indications, etc; Protection of plant variety and farmers right act; Indian patent act and amendments, patent filing; Convention on biological diversity; Implications of intellectual property rights on the commercialization of biotechnology products.

Suggested Readings

Singh BD. 2007. *Biotechnology: Expanding Horizon*. Kalyani.
http://patentoffice.nic.in
www.wipo.org
www.dbtindia.nic.in
www.dbtbiosafety.nic.in

MBB 511/ ANIMAL BIOTECHNOLOGY 3+0 SEM - I

ABT 616 (To be taught by Animal Biotechnology)

Objective

Intended to provide an overview and current developments in different areas of animal biotechnology.

Theory

UNIT-I: Structure of animal cell; History of animal cell culture; Cell culture media and reagents, culture of mammalian cells, tissues and organs, primary culture, secondary culture, continuous cell lines, suspension cultures, somatic cell cloning and hybridization, transfection and transformation of cells, commercial scale production of animal cells, application of animal cell culture for *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.
UNIT-II: Introduction to immune system, cellular and hormonal immune response, history of development of vaccines, introduction to the concept of vaccines,conventional methods of animal vaccine production, recombinant approaches to vaccine production, hybridoma

technology, phage display technology for production of antibodies, antigen-antibody based diagnostic assays including radioimmunoassays and enzyme immunoassays, immunoblotting, nucleic acid based diagnostic methods, commercial scale production of diagnostic antigens and antisera, animal disease diagnostic kits, probiotics.
UNIT-III: Structure of sperms and ovum, cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, *in vitro* fertilization, culture of embryos, cryopreservation of embryos, embryo transfer, embryo-spliting, embryo sexing, transgenic manipulation of animal embryos, different applications of transgenic animal technology, animal viral vectors, animal cloning basic concept, cloning from- embryonic cells and adult cells, cloning of different animals, cloning for conservation for conservation endangered species, ethical, social and moral issues related to cloning, *in situ* and *ex situ* preservation of germplasm, *in utero* testing of foetus for genetic defects, pregnancy diagnostic kits, anti-fertility animal vaccines, gene knock out technology and animal models for human genetic disorders.
UNIT-IV: Introduction to different breeds of cattle, buffalo, sheep, goats, pigs, camels, horses, canines and poultry, genetic characterization of livestock breeds, marker assisted breeding of livestock, introduction to animal genomics, different methods for characterization of animal genomes, SNP, STR, QTL, RFLP, RAPD, genetic basis for disease resistance, Transgenic animal production and application in expression of therapeutic proteins. Immunological and nucleic acid based methods for identification of animal species, detection of meat adulteration using DNA based methods, detection food/feed adulteration with animal protein, identification of wild animal species using DNA based methods using different parts including bones, hair, blood, skin and other parts confiscated by anti-poaching agencies.

Suggested Readings

Gordon I. 2005. *Reproductive Techniques in Farm Animals*. CABI.
Kindt TJ, Goldsby RA & Osbrne BA. 2007. *Kuby Immunology*. WH Freeman.
Kun LY. 2006. *Microbial Biotechnology*. World Scientific.
Levine MM, Kaper JB, Rappuoli R, Liu MA, Good MF. 2004. *New Generation Vaccines*. 3rd Ed. Informa Healthcare.
Lincoln PJ & Thomson J. 1998. *Forensic DNA Profiling Protocols*. Humana Press.
Portner R. 2007. *Animal Cell Biotechnology*. Humana Press.
Spinger TA. 1985. *Hybridoma Technology in Biosciences and Medicine*. Plenum Press.
Twyman RM. 2003. *Advanced Molecular Biology*. Bios Scientific.

MBB 512/ IMMUNOLOGY AND 2+1 SEM - II
BIOCHEM 506/ MOLECULAR DIAGNOSTICS

BIF 510 (To be taught by Veterinary Microbiology)

ObjectiveT
o discuss the application of various immunological and molecular diagnostic tools.

Theory

UNIT-I: History and scope of immunology; Components of immune system: organs, tissues and cells, Immunoglobulin structure and functions; Molecular organization of immunoglobulins and classes of antibodies.
UNIT-II: Antibody diversity; antigens, haptens, antigens- antibody interactions; immunoregulation and tolerance; Allergies and other hypersensitive responses; Immunodeficiency; Vaccines.
UNIT-III: Application of immunology, immunological techniques, Principles of ELISA and its applications; Monoclonal antibodies and their uses, molecular diagnostics;

Introduction to the basic principles of molecular technology and techniques used for pathogen detection.
UNIT-IV: Basics and procedures of PCR, PCR based and hybridization based methods of detection, microarrays based detection, multiplexing etc, detection of soil borne and seed born infections, transgene detection in seed, planting material and processed food, molecular detection of varietal impurities and seed admixtures in commercial consignments.

Practical

- Preparation of buffers and reagents.
- Serological tests such as bacterial slide agglutination, latex agglutination and agar gel immunodiffusion.
- Immunoassays including ELISA, western blotting, and fluorescent antibody test.
- Hybridoma technique for production of monoclonal antibodies.
- Recombinant protein antigen- production and immunization of laboratory animals.

• Extraction of DNA/RNA from pathogenic microorganisms, PCR, genotyping, diagnosis, etc.

Suggested Readings

Bloom BR & Lambert P-H. 2002. *The Vaccine Book*. Academic Press.
Elles R & Mountford R. 2004. *Molecular Diagnosis of Genetic Disease*. Humana Press.
Kindt TJ, Goldsby RA & Osbrne BA. 2007. *Kuby's Immunology*. WH Freeman.
Levine MM, Kaper JB, Rappuoli R, Liu MA & Good MF. 2004. *New Generation Vaccines.* 3rd Ed. Informa Healthcare.
Lowrie DB & Whalen R. 2000. *DNA Vaccines*. Humana Press.
Male D, Brostoff J, Roth DB & Roitt I. 2006. *Immunology.* Elsevier.
Rao JR, Fleming CC & Moore JE. 2006. *Molecular Diagnostics*. Horizon Bioscience.
Robinson A & Cranage MP. 2003. *Vaccine Protocols*. 2nd Ed. Humana Press.
Spinger TA, 1985. *Hybridoma Technology in Biosciences and Medicine*. Plenum Press.

MBB 513 NANO-BIOTECHNOLOGY 3+0 SEM - I

Objective

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

Theory

UNIT-I: Introduction to Biomacromolecules: The modern concepts to describe the conformation and dynamics of biological macromolecules: scattering techniques, micromanipulation techniques, drug delivery applications etc.
UNIT-II: Cellular engineering: signal transduction in biological systems, feedback control signaling pathways, cell-cell interactions etc. Effects of physical, chemical and electrical stimuli on cell function and gene regulation.
UNIT-III: Chemical, physical and biological properties of biomaterials and bioresponse: 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-IV: Preparation and characterization of nanoparticles; Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

Suggested Readings

Nalwa HS. 2005. *Handbook of Nanostructured Biomaterials and their Applications in Nanobiotechnology*. American Scientific Publ.
Niemeyer CM & Mirkin CA. 2005. *Nanobiotechnology*. Wiley Interscience.

MBB 514/ FOOD BIOTECHNOLOGY 2+1 SEM - I

FST 519 (To be taught by Molecular Biology & Biotechnology)

ObjectiveT

his is a special course designed for students of FST to acquaint with the fundamentals and application of biotechnology in relation to raw materials for food processing, nutrition, food fermentations, waste utilization and better use of genetic resources.

Theory

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UNIT-I: Prospects of biotechnology- definition, history, scope and applications, Application of biotechnology in food (food industries), pharmaceuticals and agriculture, food/plant waste utilization, biogas plants; organisms and their utilization for the production of fermented foods and beverages.
UNIT-II: Structure and function of nucleic acids; Recombinant DNA technology: restriction and other DNA modifying enzymes, vectors, DNA libraries, gene cloning, PCR, gene expression, etc.
UNIT-III: Applications of genetical control mechanism in industrial fermentation process, (induction, manipulation and recombination); Biomass production by using various microorganisms; Cell and tissue culture, Secondary metabolites synthesis; Transgenic organisms (GMOs): methods, applications, safety aspects, etc.
UNIT-IV: Biotechnology for enhancing quality attributes of food; Enzyme biotechnology; Enzyme immobilization techniques and their applications in food industry; Microbial transformations; Potential impact and future aspects of biotechnology in food industry.

Practical

Study of auxotroph, Micropropogation through tissue culture, Strain improvement through U.V. mutation, Mutagenesis using chemical mutagens (ethidium bromide), Isolation and analysis of genomic DNA from *E.coli* and *Bacillus cereus,* Isolation of protoplasts, Introduction to the techniques of ELISA / Southern blot / DNA fingerprinting / Agarose

gel electrophoresis, etc.

Suggested Readings

Bains W. 1993. *Biotechnology from A to Z*. Oxford Univ. Press.
Joshi VK & Pandey A.1999. *Biotechnology: Food Fermentation*. Vols. I, II. Education Publ.
Knorr D.1982. *Food Biotechnology*. Marcel Dekker.
Lee BH. 1996. *Fundamentals of Food Biotechnology*. VCH.
Perlman D. 1977-1979. *Annual Reports of Fermentation Processes*.
Prescott SC & Dunn CG. 1959. *Industrial Microbiology*. McGraw Hill.
Ward OP. 1989. *Fermentation Biotechnology*. Prentice Hall.

MBB 515/ BIOTECHNOLOGY OF HORTICULTURAL 2+1 SEM - II
FSC 509 CROPS

(To be taught by Molecular Biology & Biotechnology)

Objective

Understanding the principles, theoretical aspects and developing skills in biotechnology of horticultural crops.

Theory

UNIT-I : Harnessing bio-technology in horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture.

UNIT-II: Callus culture – types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis, artificial seeds.

UNIT-III: Use of bioreactors and *in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues, ex vitro, establishment of tissue cultured plants, rapid clonal propagation.

UNIT-IV: Physiology of hardening - hardening and field transfer, organ culture – meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, haploids, *in vitro* mutation, , cryopreservation.

UNIT-V: Wide hybridization, *in vitro* pollination and fertilization, protoplast culture and fusion, identification of somatic hybrids and cybrids, genetic engineering and transformation, use of molecular markers, achievements of biotechnology in horticultural crops.

Practical

An exposure to low cost, commercial and homestead tissue culture laboratories, media preparation, inoculation of explants for clonal propagation, callus induction and culture, regeneration of plantlets from callus, sub-culturing, techniques on anther, ovule, embryo culture, somaclonal variation, protoplast isolation and culture, genetic transformation.

Suggested Readings

Bajaj YPS. (Ed.). 1989. *Biotechnology in Agriculture and Forestry*. Vol. V, *Fruits*. Springer.
480
Brown TA. 2001. *Gene Cloning and DNA Analysis and Introduction.* Blackwell Publ.
Chopra VL & Nasim A. 1990. *Genetic Engineering and Biotechnology – Concepts, Methods and Applications.* Oxford & IBH.
Gorden H & Rubsell S. 1960. *Hormones and Cell Culture*. AB Book Publ.
Keshavachandran R & Peter KV. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer*. Orient & Longman (Universal Press).
Keshavachandran R, Nazeem PA, Girija D, John PS & Peter KV. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. Vols. I, II. New India Publ. Agency.
Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK & Mohanadas S. 2001. *Biotechnology of Horticultural Crops*. Vols. I-III. Naya Prokash.
Pierik RLM. 1987. *In vitro Culture of Higher Plants*. Martinus Nijhoff Publ.
Skoog F & Miller CO. 1957. *Chemical Regulation of Growth and Formation in Plant Tissue Culture in vitro. Symp. Soc. Exp. Biol.* 11: 118-131.
Vasil TK, Vasi M, While DNR & Bery HR.1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture*. Planum Press.
Williamson R. 1981-86. *Genetic Engineering*. Vols. I-V. Academic Press.

MBB 553/ BIOSTATISTICS AND COMPUTERS 2+1 SEM - I
STAT534/ (To be taught by Statistics)
FST531/
SOC512

ObjectiveT

his is a course of applied Statistics to be taken by M.Sc. students of Biotechnology, FST

and Sociology departments of CoBS&H. They are exposed to various statistical methods to analyze their experimental data.

Theory

UNIT-I: Aims, scope and idea of elementary statistics; Measures of central tendency and dispersion, skewness and kurtosis.

UNIT-II: Concept of probability and probability laws, mathematical expectation, moments, moments generating function; Standard probability distributions- Binomial, Poisson and Normal distributions.

UNIT-III: Tests of significance based on Z, χ_2, t and F statistics; Correlation and regression, curve fitting by least squares methods.

UNIT-IV: Basic principles, organization and operational aspects of computers, operating systems. Introduction to MS-Office, MS-Word, MS-Excel. Statistical Data analysis based on above topics through MS-Excel.

Practical

- Data analysis using probability, test of significance
- Correlation and regression analysis
- Usage of MS-Windows
- Exercises on test processing, spreadsheet and DBMS
- SPSS

Suggested Readings

Agarwal BL. 2003. *Basic Statistics*. New Age.
Gupta SP. 2004. *Statistical Methods*. S. Chand & Sons.
Dutta NK. 2002. *Fundamentals of Bio-Statistics*. Kanishka Publ.,Wiley Eastern.

MBB 555/ INTRODUCTION TO BIOINFORMATICS 2+1 SEM - I
BIF 501/ (To be taught jointly by Molecular Biology & Biotechnology,
ABT 608/ Bioinformatics, Animal Biotechnology)
FSC 604

ObjectiveT

o impart an introductory knowledge about the subject of bioinformatics to the students studying any discipline of science.

Theory

UNIT-I: Introduction, biological databases – primary, secondary and structural, Protein and Gene Information Resources – PIR, SWISSPROT, PDB, genebank, DDBJ. Specialized genomic resources.

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UNIT-II: DNA sequence analysis, cDNA libraries and EST, EST analysis, pairwise alignment techniques, database searching, multiple sequence alignment.

UNIT-III: Secondary database searching, building search protocol, computer aided drug design – basic principles, docking, QSAR.

UNIT-IV: Analysis packages – commercial databases and packages, GPL software for Bioinformatics, web-based analysis tools.

Practical

- Usage of NCBI resources
- Retrival of sequence/structure from databases
- Visualization of structures
- Docking of ligand receptors
- BLAST exercises.

Suggested Readings

Attwood TK & Parry-Smith DJ. 2003. *Introduction to Bioinformatics*. Pearson Edu.
Rastogi SC, Mendiratta N & Rastogi P. 2004. *Bioinformatics: Concepts, Skills and Applications*. CBS.

MBB 556 ENVIRONMENTAL BIOTECHNOLOGY 3+0 SEM - II

ObjectiveT

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

Theory

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, filteration, 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.

Suggested Readings

Evans GM & Furlong JC. 2002. *Environmental Biotechnology: Theory and Application*. Wiley International.
Jordening H-J & Winter J. 2006. *Environmental Biotechnology: Concepts and Applications*. Wiley-VCH Verlag.

MBB 601 ADVANCES IN PLANT 3+0 SEM - I MOLECULAR BIOLOGY

ObjectiveT
o discuss the specialized topics and recent advances in the field of plant molecular biology.

Theory

UNIT-I: *Arabidopsis* in molecular biology, Forward and Reverse Genetic Approaches, Transcriptional and post-transcriptional regulation of gene expression, isolation of promoters and other regulatory elements.
UNIT-II: RNA interference, Transcriptional gene silencing, Transcript and protein analysis, use of transcript profiling to study biological systems.

UNIT-III: Hormone regulatory pathways: Ethylene, Cytokinin, Auxin and ABA, SA and JA; ABC Model of Floral Development, Molecular basis of self incompatibility, Regulation of flowering: photoperiod, vernalization, circadian rhythms.
UNIT-IV: Molecular biology of abiotic stress responses: Cold, high temperature, submergence, salinity and drought; Molecular Biology of plant-pathogen interactions, molecular biology of *Agrobacterium* Infection, Molecular biology of *Rhizobium* infection (molecular mechanisms in symbiosis), Programmed cell death in development and defense.

Suggested Readings

Buchanan B, Gruissen W & Jones R. 2000. *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists, USA.
Lewin B. 2008. *Gene IX.* Peterson Publications/ Panima.
Malacinski GM & Freifelder D. 1998. *Essentials of Molecular Biology*. 3rd Ed. Jones & Bartlett Publ.
Nelson DL & Cox MM. 2007. *Lehninger's Principles of Biochemistry*. WH Freeman & Co.
Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. *Molecular Biology of the Gene.* 6th Ed. Pearson Edu.

MBB 602 ADVANCES IN GENETIC ENGINEERING 3+0 SEM - I

ObjectiveT
o discuss the specialized topics and advances in field of genetic engineering and their application in plant improvement.

Theory

UNIT-I: General overview of transgenic plants; Case studies: Genetic engineering of herbicide resistance, Transgenic plants resistant to insects/pests, Genetic engineering of abiotic stress tolerance, Engineering food crops for quality, Genetically engineered pollination control, Induction of male sterility in plants.
UNIT-II: Molecular farming of plants for applications in veterinary and human medicine systems: Boosting heterologous protein production in transgenics, Rapid production of specific vaccines, High-yield production of therapeutic proteins in chloroplasts.
UNIT-III: 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; Gene stacking; Pathway engineering; Marker-free transgenic development strategies; 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.

Suggested Readings

Christou P & Klee H. 2004. *Handbook of Plant Biotechnology*. John Wiley & Sons.
Specific journals mentioned later.

MBB 603 ADVANCES IN MICROBIAL BIOTECHNOLOGY 3+0 SEM - II

ObjectiveT
o discuss specialized topics about industrially important microorganisms.

Theory

UNIT-I: Fermentative metabolism and development of bioprocessing technology, processing and production of recombinant products; isolation, preservation and improvement of industrially important microorganisms.
UNIT-II: Immobilization of enzymes and cells; Batch, plug flow and chemostate cultures; Computer simulations; Fed-batch and mixed cultures; Scale-up principles; Down stream processing etc.
UNIT-III: Current advances in production of antibiotics, vaccines, and biocides; Steroid transformation; Bioreactors; Bioprocess engineering; Production of non-microbial origin products by genetically engineered microorganisms.
UNIT-IV: Concept of probiotics and applications of new tools of biotechnology for quality feed/food production; Microorganisms and proteins used in probiotics; Lactic acid bacteria as live vaccines; Factors affecting delignification; Bioconversion of substrates,

anti-nutritional factors present in feeds; Microbial detoxification of aflatoxins; Single cell protein, Bioinsecticides; Biofertilizers; Recent advances in microbial biotechnology.

Suggested Readings

Specific journals and published references.

MBB 604/ VSC604/ FLA 605 ADVANCES IN CROP BIOTECHNOLOGY 3+0 SEM - I

ObjectiveT
o discuss specialized topics on the application of molecular tools in breeding of specific crops.

Theory

UNIT-I: Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available tissue culture, transformation, molecular marker and genomic tools for crop improvement.
UNIT-II: 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-III: Molecular breeding: constructing molecular maps; integrating genetic, physical and molecular maps; diversity assessment and phylogenetic analysis; molecular tagging of genes/traits; selected examples on marker assisted selection of qualitative and quantitative traits.
UNIT-IV: Discussion on application of molecular, transformation and genomic tools for the genetic enhancement in some major cereal, legume, oilseed, vegetable and horticultural crops.

Suggested Readings

Specific journals and published references.

MBB 605/ BIOCHEM 606/ PP 602 ADVANCES IN FUNCTIONAL GENOMICS, PROTEOMICS AND METABOLOMICS 3+0 SEM - II

(To be taught jointly by Molecular Biology & Biotechnology, Biochemistry, Plant Physiology)

ObjectiveT
o discuss recent advances and applications of functional genomics and proteomics in agriculture, medicine and industry.

Theory

UNIT-I: Genome sequencing and functional genomics; Human, animal, plant, bacterial

and yeast genome projects; genome annotation; *ab initio* gene discovery; functional annotation and gene family clusters; etc.
UNIT-II: Functional analysis of genes; RNA-mediated interference; gene knockoffs; Gene traps/ T-DNA insertion lines; homologous recombination; microarray profiling; SAGE; SNPs/variation; yeast-two hybrid screening; gene expression and transcript profiling; EST contigs; EcoTILLING; allele/gene mining; synteny and comparative genomics; Genome evolution, speciation and domestication etc.
UNIT-III: Proteomics: protein annotation; protein separation and 2D PAGE; mass spectroscopy; protein microarrays; protein interactive maps; structural proteomics: protein structure determination, prediction and threading, software and data analysis/ management, etc.
UNIT-IV: Metabolic pathway engineering, Discussion on selected papers on functional genomics, metabolomics, proteomics, integrative genomics etc.

Suggested Readings

Specific journals and published references.

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MBB 606 COMMERCIAL PLANT TISSUE CULTURE 2+0 SEM - I

ObjectiveT

o discuss the commercial applications of plant tissue culture in agriculture, medicine and industry.

Theory

UNIT-I: Micropropagation 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 ethic issues; management and commercialization.
UNIT-IV: Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/industries.

Suggested Readings

Specific journals and published references.

MBB 607/ ADVANCES IN ANIMAL BIOTECHNOLOGY 2+0 SEM - II

ABT707 (To be taught by Animal Biotechnology)

Objective

Intended to provide cutting edge knowledge on advances in different areas of animal biotechnology.

Theory

UNIT-I: Advances in animal cell culture technology, suspension culture technology, advances in commercial scale productions of mammalian cells.
UNIT-II: Advances in cell cloning and cell hybridization, advances in monoclonal antibody production technology, Advances in diagnostic technology, Computational vaccinology, reverse genetics based vaccines.
UNIT-III: Advances in embryo manipulation, knock out and knock in technology, advances in animal cloning technology, stem cell technology, Advances in development of animal models for human diseases using transgenic animal technology.
UNIT-IV: Advances in genetic basis for animal disease resistance, Molecular methods for animal forensics, Advances in animal genomics, proteomics.

Suggested Readings

Selected articles from journals.

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PLANT MOLECULAR BIOLOGY & BIOTECHNOLOGY

List of Journals

- Advances in Botanical Research
- Advances in Enzyme Regulation
- Advances in Enzymology
- Advances in Genetics
- Agricultural and Biological Research
- Analytical Biochemistry
- Annals of Botany

- Archives of Biochemistry and Biophysics
- Archives of Microbiology
- Biochemical and Biophysical Research Communication
- Biochemical Genetics
- Biochemistry
- Biotechnology and Bioengineering
- Critical Reviews in Plant Sciences
- Crop Science
- EMBO Journal
- Euphytica
- Genetic and Plant Breeding
- Genome
- Indian Journal of Genetics and Plant Breeding
- Journal of Biotechnology
- Journal of Experimental Botany
- Journal of General Microbiology
- Journal of Heredity
- Journal of Plant Biochemistry and Biotechnology
- Journal of Plant Biology
- Molecular and Cellular Biochemistry
- Molecular Breeding
- Molecular Genetics and Genomics
- Nature
- Nature Biotechnology
- Plant Cell
- Plant Molecular Biology
- Plant Physiology
- Plant Physiology and Biochemistry
- Proceedings of The National Academy of Sciences (USA)
- Science
- Trends in Biochemical Sciences
- Trends in Biotechnology
- Trends in Cell Biology
- Trends in Food Science and Technology
- Trends in Genetics
- Trends in Microbiology
- Trends in Plant Sciences

e-Resources

- National Center for Biotechnology Information
  - http://www.ncbi.nlm.nih.gov/
- The World Wide Web Virtual Library: Biotechnology.
  - http://www.cato.com/biotech/

- The Transgenic/Targeted Mutation Database (TBASE)
  - http://www.bis.med.jhmi.edu/Dan/tbase/tbase.html
- Primer on Molecular Genetics
  - http://www.bis.med.jhmi.edu/Dan/DOE/intro.html.
- Bioportal
  - http://bioportal.gc.ca/english/BioPortalHome.asp
- Access Excellence
  - http://www.gene.com/ae
- BioTech Biosources Database: Indiana University
  - http://biotech.chem.indiana.edu/
- Information Systems for Biotechnology
  - http://gophisb.biochem.vt.edu/
- All About The Human Genome Project (HGP)
  - http://www.genome.gov/
- *Human Genome Project at the Sanger Institute*
  - http://www.sanger.ac.uk/HGP/
- UCSC Genome Browser

- http://genome.ucsc.edu/
- Gramene
- www.gramene.org/
- The Institute for Genomic Research
- www.tigr.org

Suggested Broad Topics for Master's and Doctoral Research

- Micropropagation of important crop plants, cash crops, ornamentals, forest and horticultural trees, medicinal and aromatic plants.
- Development of transgenics in field crops for resistance against biotic and abiotic stresses, and to improve the nutritional quality, etc.
- DNA fingerprinting of important plant species and germplasm.
- Development of molecular markers (SNP, SSR, transposable elements, etc) and their utilization for genetic diversity and phylogenetic analysis.
- Molecular mapping and marker-assisted selection for major-gene traits in crop species.
- Value-addition including biopesticides, biofertilizers, biofuels, biodegradable plastics, secondary metabolites, etc.
- Genome sequencing and functional analysis of genes of important organisms.
- Allele mining, proteomics, genomics and metabolic engineering for crop improvement.
- Immobilization of enzymes/microorganisms.
- Protein engineering.
- To develop crops with improved mineral (Fe, Zn, Vitamin A, etc) bioavailbility.
- Biodiversity and conservation of endangered plant species.
- Bioprocess engineering and down stream processing.