University of Mysore
Department of Studies in Biotechnology
Manasagangotri, Mysore – 570 006
M.Sc. Biotechnology Programme (2 Years/4 Semesters)

Programme objectives

The main objective of this M.Sc. Biotechnology programme is

- To provide quality teaching and training in multidisciplinary areas of Biotechnology and nurture students to meet the needs of the society and industry.
- To cater to the national and global requirement of trained manpower in the area of Biotechnology.
- To create and sustain excellent research and teaching ambience for future leaders and innovators.
- To establish collaborations with other academic institutions at national and international levels to reinforce education and research activities.
- To train the students in technology-based entrepreneurship for socio-economic development.
- Skill development training to bridge the gap between academia and industry.

Programme Outcomes

The M.Sc., programme in Biotechnology is in high demand among life science programmes in the University. The programme is supported by DBT Govt. of India under HRD scheme attracting the students from all over the country. Successful completion of this programme will result in students;

- Having strong foundation in understanding of basic biology in both prokaryotic and eukaryotic systems at molecular level. Further the student will be able to learn cutting edge technology in the field of Biotechniques, Cell biology, molecular biology, Genetic Engineering, Plant, Animal and Microbial Biotechnology, microbiology, immunology, Food and Environmental Biotechnology and Bioinformatics.
- Having hands-on practical skills along with their respective theoretical knowledge, which will help in their research carrier in academic institutions and industries.
- Having improved skills for teaching in academic institutions.
- Having competitive skills and spirit in the field of life sciences both in India and abroad for pursuing higher education.

Pedagogies employed in the M.Sc., programme

- Class room teaching with audio-visual aids, power point presentation information and communications technology in addition to black board and chalk.

- Tutorial classes with one to one interaction or with small student groups.
- Practical experiments will be performed by students Individually.
- Students will be presenting seminars/research papers in every semester.
- Continuous evaluation of students with regular tests/assignments/quiz .
- Viva voce examinations of the students by examiners for improving their communication/expression skills.
- Students will carry out project work on a research problem.
- Special Lectures by eminent scientists/academicians.

New Scheme of Study (2018- 2019 Onwards)

Master's Degree Program in Biotechnology

Credits to be earned	**76**
Core papers	51 credits
Soft core	21 credits
Open elective paper*	04 credits

*Open elective shall be entirely from different discipline of study

Credit matrix for Master's Degree Program in Biotechnology

Credits to be earned	**I**	**II**	**III**	**IV**	**Total Credits**
Hard Core	14	14	14	09	51 credits
Soft Core	06	06	06	03	21 credits
Open elective	-	04	-	-	04 credits
Total	20	24	20	12	76

I Semester

Paper Code	**Title of the course**	**HC/SC/ OE/etc**	**L**	**T**	**P**	**Credits**
16941	Bioanalytical Techniques	HC	3	0	0	3
16942	Microbiology	HC	3	0	0	3
16943	Biochemistry	HC	3	0	0	3
	Practical-1 (Bioanalytical Techniques, Microbiology, Biochemistry)	HC	0	0	5	5
SOFTCORE (Choose any TWO from the below list)						
16944	Cancer Biology	SC	3	0	0	3
16945	Food & Environmental Biotechnology	SC	3	0	0	3
16946	Biostatistics & Bioinformatics	SC	3	0	0	3

II Semester

Paper Code	**Title of the course**	**HC/SC/ OE/etc**	**L**	**T**	**P**	**Credits**

16951	Molecular Biology	HC	3	0	0	3
16952	Genetic Engineering	HC	3	0	0	3
16953	Immunotechnology	HC	3	0	0	3
	Practical-2 (Molecular Biology, Genetic Engineering, Immunotechnology)	HC	0	0	5	5
SOFTCORE (Choose any TWO from the below list)						
16954	Molecular Genetics	SC	3	0	0	3
16955	Genomics & Proteomics	SC	3	0	0	3
16956	Cell Biology and Cellular Signalling	SC	3	0	0	3
	OPEN ELECTIVE (Choose from other department)	OE				4
16957	Biotechnology and its applications (For other discipline students)	OE	4	0	0	4

III Semester

Paper Code	Title of the course	HC/SC/ OE/etc	L	T	P	Credits
16961	Plant Biotechnology	HC	3	0	0	3
16962	Animal Biotechnology	HC	3	0	0	3
16963	Bioprocess Technology	HC	3	0	0	3
	Practical-3 (Plant and Animal Biotechnology, Bioprocess Technology)	HC	0	0	5	5
SOFTCORE (Choose any TWO from the below list)						
16964	Molecular Diagnostics	SC	3	0	0	3
16965	Natural Products &Drug Discovery	SC	3	0	0	3
16966	Nanobiotechnology	SC	3	0	0	3

IV Semester

Paper Code	Title of the course	HC/SC/ OE/etc	L	T	P	Credits
	SOFTCORE (Choose any ONE from the below list)					
	Stem Cell & Regenerative Medicine	SC	3	0	0	3
	Molecular Plant Pathology	SC	3	0	0	3
	Project work/Dissertation*	HC	0	3	6	9

*** Dissertation should be in-house only and should be allotted to the students in the III Semester itself.**

Additional Softcores

Paper Code	Title of the course	HC/SC/ OE/etc	L	T	P	Credits
	Bioentrepreneurship	SC	3	0	0	3
	Seed Health and Diagnostics	SC	3	0	0	3

Hardcore papers

Semester I

Bioanalytical Techniques (HC)

48 h

Objectives are:

- To study the pricnciples of various separation and analytical techniques in biology.
- To understand the methodology and applications of the techniques.

Course outcome:

The student will:

- Understand the principles and basic of various biochemical and analytical techniques
- Understand the applications of these techniques.
- Understand the separation and characterization of biomolecules using these techniques.

Unit-I

General considerations, pH and buffers, cell disruption techniques.

Chromatographic techniques: General principles, Sample preparation, Selection of chromatographic system, Low pressure column chromatography, HPLC, Adsorption chromatography, Partition chromatography, Ion exchange chromatography, Exclusion chromatography, Affinity chromatography, GLC, TLC, Paper chromatography.

Unit-II

Electrophoretic Techniques: General principles, Support media, Native gels, SDS-PAGE, IEF, 2D gel electrophoresis, Agarose gel electrophoresis, Pulse field gel electrophoresis (PFGE), Capillary electrophoresis (CE).

Centrifugation Techniques: Introduction, Basic principles of sedimentation, Types of centrifuges and their uses, Preparative centrifugation- differential and density gradient separation, Analytical ultracentrifuges and their applications.

Unit-III

Spectroscopic techniques: Introduction, UV and visible light spectroscopy, IR and Raman spectroscopy, Electron Spin Resonance (ESR), NMR, Spectrofluorimetry, Luminometry, Atomic spectroscopy, X-ray diffraction, ORD, CD.

Mass spectrometric techniques: Introduction, mass spectrometer, Ionization techniques- Electron impact ionization (EI), Electrospray Ionization, Chemical ionization (CI), Field ionization (FI), MALDI, Ion disruption methods, Ion desorption and evaporation methods, Analyzers- Magnetic sector, time-of-flight, quadropole, ion trap, Detectors- electron multipliers, Tandem mass spectrometry, applications.

Unit-IV

Microscopy techniques: Light microscopy, phase contrast microscopy, fluorescence microscopy, electron microscope- TEM and SEM, confocal microscopy, flow cytometry-FACS.

Radioisotope techniques: Nature of radioactivity, detection and measurement, GM counter, scintillation counting, autoradiography, Safety aspects and applications of radioisotopes in biology.

Electrochemical techniques: Introduction, Principles, Redox reactions, Types of electrodes-pH electrode, ion-sensing electrodes, gas sensing electrodes, oxygen electrode, Biosensors.

Microbiology (HC)

48 h

Objectives are:

- To study the early discoveries and recent developments in microbiology.
- To study the various culture techniques employed for microbes and their control.
- To study the molecular mechanisms of host pathogen interactions.

Course outcome the student will:

- Understand the major discoveries and development in microbiology.
- Understand the isolation, characterization and control the growth of microorganisms.
- Understand the mechanism of host pathogen interactions and pathogen-induced diseases.

Unit-I

The beginning of microbiology and Microbial Characteristics

Introduction to Microbiology and Microbes; History and scope of Microbiology – Hook, Antony van Leeuwehnoek and Cohn; Contribution of Pasteur and Koch. Morphology, structure, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance. Culture collection and Maintenance of cultures.

Unit-II

Microbial Taxonomy and Microbial diversity

Microbial taxonomy and evolution, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, Bacterial endospores, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilic archae. Virus and bacteriophages, general properties of viruses, viral structure, sub-viral particles – viroids and prions. Eukarya: algae, fungi, slime moulds and protozoa; extremophiles and unculturable microbes.

Unit-III

Microbial Growth and Control

Microbial growth: Growth curve, measurement of growth, synchronous growth, continuous culture, factors affecting growth like temperature, acidity, alkalinity, water availability and oxygen. Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, biological control of microorganisms.

Microbes and environment: Nutrient cycles; microbial communication system; quorum sensing, microbial fuel cells; prebiotics and probiotics.

Unit-IV

Beneficial and Harmful effects of Microorganism

Beneficial aspects of microbes and their metabolites in dairy and food industry, Role of microbes in Environmental safety. Important microbial diseases of Plants caused by fungi, bacteria and viruses. Important infectious diseases of humans, caused by bacteria, protozoa and viruses - tuberculosis, malaria, AIDS, rabies. Pathogenic fungi, emerging and resurgent infectious diseases.

Biochemistry (HC)

48 h

Objectives are:

- To study the properties of various biomolecules in the cell.
- To study the metabolism of the biomolecules
- To study the principles of enzyme action

Course outcome the student will:

- Understand the structure and classification of carbohydrates, amino acids, lipids proteins and nucleic acids.
- Understand the mechanism of enzyme action.
- Have an overview of metabolism of carbohydrates, amino acids, nucleic acids and lipids, and the energits involved

Unit-I

Carbohydrates, Lipids and Nucleic acids

Carbohydrates: Structure of starch, glycogen and bacterial cell wall polysaccharides. Structure and biological significance of glycoproteins and proteoglycans.

Lipids: Classification, structure and functions of storage and membrane lipids- TAG, phospholipids, sphingolipids, glycolipids, isoprenoids and eicosanoids.

Nucleic acids: Structure of DNA, chemical synthesis of DNA, Isolation and characterization. structure of RNA, types and functions.

Unit-II

Proteins: Amino acids- structure and functional group properties, peptide bond, structural organization of proteins- primary, secondary, super-secondary, tertiary and quaternary, protein structures- myoglobin, collagen, keratin, immunoglobulin, Ramachandran plot, end group analysis, primary structure determination, synthesis of peptides, structure-function relationships in model proteins- Myoglobin, Haemoglobin, denaturation and renaturation of proteins- Ribonuclease A

Unit-III

Enzymology

Classification, enzyme activity, Michaelis-Menten kinetics, LB plot, inhibition - competitive, uncompetitive, non-competitive, mixed, partial, substrate inhibition, suicide inhibition, determination of Ki, active site, allosterism - ATCase, isoenzymes- LDH, catalytic strategies, co-enzymes and cofactors, multienzyme complexes- PDC.

Unit-IV

Bioenergetics

Electron transport chain and Oxidative phosphorylation: organization of respiratory chain complexes, structure and function of components, Oxidative phosphorylation. Mechanism of ATP synthesis, ATP synthase complex, proton motive force, Mitchell's hypothesis, mitochondrial permeability transition pore and its implications. Integration of metabolic pathways to bioenergetics- Glycolysis, TCA cycle, Glycogen metabolism, Pentose phosphate pathway, Gluconeogenesis, Amino acid metabolism, fatty acid metabolism, Nucleic acid metabolism.

Practical-1

Objectives are:

- To learn good laboratory practices
- To learn the preparations of various reagents and culture media.
- To learn the isolation and estimations of biomolecules using different methods.

Course outcome the student will:

- Understand the basics of laboratory reagents/solutions/ buffers and their preparations with respect to percent solution, molar and normal solutions, and pH
- Understand the quantitative estimations of various biomolecules using spectroscopic methods.
- Understand the isolation and characterization of microorganisms using staining techniques.

Experiments

- Measurement of pH
- Preparation buffers and solutions
- Determination of pKa of amino acids
- Estimation of reducing sugar by DNS method
- Estimation of proteins by Lowry's method
- Estimation of proteins by Bradford's method
- Estimation of proteins by Bicinchonic acid method
- Wavelength scan of proteins and nucleic acids
- Ascending, descending and circular paper chromatography for separation of amino acids
- TLC of amino acids (1D and 2D)
- UV-Visible Spectrophotometry
- Column chromatography- gel filtration
- Gel electrophoresis- native and SDS-PAGE and estimation of molecular weight of proteins
- Demonstration of HPLC, LC-MS, XRD, NMR, Confocal and Electron microscopy
- Assay of acid phosphatase- Specific activity, effect of pH, determination of Km, Vmax, IC50 value
- Preparation of liquid and solid media for growth of microorganisms
- Isolation and maintenance of organisms by plating, streaking and serial dilution methods, slants and stab cultures, storage of microorganisms
- Isolation of pure cultures from soil and water

- Growth, growth curve; measurement of bacterial population by turbidometry and serial dilution methods. Effect of termperature, pH, carbon and nitrogen sources on growth.
- Microscopic examination of bacteria, yeast and molds and study of organisms by gram stain, acid fast stain and staining for spores.
- Assay of antibiotics and demonstration of antibiotic resistance.
- Biochemical characterization of selected microbes

Semester II

Molecular Biology (HC)

48 h

Objectives are:

- To study the central concepts of molecular biology (Central Dogma of Molecular Biology).
- To study the molecular mechanism of storage and transfer of genetic information from one generation to next generation.

Course outcome the student will:

- Understand the molecular process of replication, transcription, translation in prokaryotes and eukaryotes
- Understand the regulation of gene expression in prokaryotes and eukaryotes

Unit-I

Introduction of DNA as genetic material, Central dogma of molecular biology

DNA helix topology: closed and super-coiled DNA, DNA topoisomerases.

DNA replication: Semiconservative, bidirectional, semidiscontinuous replication, Enzymes in DNA replication, DNA Pol I, II, III, helicases, replication in single stranded DNA viruses (M 13 and ΦX174), replication in prokaryotes- initiation, elongation and termination. Eukaryotic DNA replication, replicons, eukaryotic DNA polymerases, role of other proteins and enzymes in replication, end-replication problem, telomeric DNA and telomerase, Replication of organelle genomes, fidelity of replication, inhibitors of replication.

Unit-II

Transcription: Transcription unit, RNA polymerase in prokaryotes, bacterial promoters, mechanism of transcription- initiation, elongation and termination, eukaryotic transcription, eukaryotic RNA polymerases, eukaryotic promoters- Class I, II, III, Enhancers and silencers, transcription factors, initiation, elongation and termination of transcription, inhibitors of transcription, mRNA processing- capping, polyadenylation, splicing, rRNA and tRNA processing, structural organization of mRNA, tRNA and rRNA, nuclear export of mRNA and mRNA stability.

Genetic code: Elucidation, triplet binding assay, Wobble hypothesis.

Unit-III

Translation: Composition and ultrastructure of prokaryotic and eukaryotic ribosomes, partial reconstitution experiments, amino acid activation, amino acylation of tRNA, aminoacyl tRNA synthetases, prokaryotic and eukaryotic translation- mechanism of initiation, elongation and termination, inhibitors of translation

Protein localization: Synthesis of secretory proteins and membrane proteins, import into nucleus, mitochondria, chloroplasts and peroxisomes, post translational modifications- signal cleavage, covalent modification, Protein folding, protein degradation pathway.

Unit-IV

Regulation of gene expression in Prokaryotes: Basic control circuits, positive and negative regulation, operon concept-*lac*, *ara* and *trp* operons, catabolite repression, regulatory elements in prokaryotes, attenuation, antitermination, stringent response, regulation of gene expression in bacteriophage - lytic and lysogenic cycle.

Regulation of gene expression in Eukaryotes: Cis control elements- promoters, enhancers, Trans acting factors, DNA binding motifs of transcription factors, mechanism of regulation by transcription factors- activators and repressors, NFkB pathway, role of chromatin in regulating gene expression and gene silencing, chromatin remodeling complexes, histone acetyl transferase and deacetylase, DNA methylation and gene regulation, hormonal regulation of gene expression (peptide and steroid hormones), post- transcriptional control- alternative splicing, RNA editing, translational control- regulation of ferritin and transferrin receptor mRNA, RNA interference, gene silencing by siRNA and miRNA.

Genetic Engineering (HC)

48 h

Objectives are:

- To study the basics of genetic engineering.
- To study the applications of various plasmids/vectors, blotting and PCR technique in cloning.
- To study the importance and applications of gene therapy and transgenics.

Course outcome the student will:

- Understand the principle and methodology employed in DNA recombinant technology.
- Understand the importance of enzymes and gene analysis techniques.
- Understand the process of cloning and expresession of genes.
- Understand the applications of gene therapy and transgenics

Unit-I

Cloning and Expression vectors: Plasmids, lambda vectors, M13 Phage, cosmids, phagemids, Artificial chromosome vectors-YACs, PACs and BACs, plant and animal viruses as vectors, Transposons, Expression vectors- prokaryotic (pRSET, pET), eukaryotic (pcDNA3, pCEP), Baculovirus and Pichia vector system, plant based vectors- Ti and Ri, binary and shuttle vectors.

Unit-II

Gene manipulation

Restriction enzymes, restriction mapping, cloning in plasmid, Phage and cosmid vectors, insertion of foreign DNA into host cells-transformation, electroporation, transfection-transient and stable, screening methods for transformants, downstream processing of recombinant proteins, affinity tags- His-tag, GST-tag, MBP-tag, Fc-tag. Construction and

screening of genomic and cDNA libraries, chromosome walking, Chromosome Jumping, BAC libraries and assembly of BACs into contigs.

Unit-III

Gene analysis techniques

Hybridization techniques- Southern, Northern, South-western, Far-western, Colony hybridization, fluorescence *in situ* hybridization, molecular probes-preparation, labelling, amplification, applications, Polymerase chain reaction-Principle, primer designing, Types- RT-PCR, realtime PCR, colony PCR, Multiplex PCR, Hot-start PCR, asymmetric PCR, Sequencing methods- chemical sequencing of DNA (Maxam and Gilberts methods and Sangers dideoxy method), automated DNA sequencing, sequencing by DE-MALDI-TOFMS, microarray. ChIP and Chip-on-chip techniques

Unit-IV

Gene therapy, transgenics and Genome editing

Ex vivo and *in vivo* gene therapy, Vectors and other delivery systems for gene therapy, In-vitro gene therapy, gene therapy of genetic diseases: eg. Neurologocal, metabolic disorders and cystic fibrosis, viruses for gene therapy- lentivirus, adenovirus. Gene targeting, knock-out mice, genome editing by CRISPR-CAS.

Immunotechnology (HC)

48h

Objectives are:

- To study the basics of defense system with respect to innate immunity.
- To study cellular and humoral bases of immunity.
- To study Immune responses in autoimmunity, tumor environment, transplantation and immune deficiency.
- To study immunological techniques and their applications.

Course outcome the student will:

- Understand the primary and secondary immune responses in cell mediated responses and production of cytokines and co-stimulatory molecules.
- Understand the basics involved in cell mediated and humoral mediated defense mechanism.
- Understand the molecular/biochemical process involved in the development of autoimmune diseases and tumor, transplantation and hypersensitive reactions.
- Understand the principles and applications of immunotechniques

Unit-I

Immunity and nonspecific immune system: Immunity, mechanical, chemical and physiological factors, phagocytosis, humoral factors, lymphocytic cells.

Antigens and immunogenicity: The immune response, immunogenicity, molecular differences in epitope structure.

Imunoglobulins: General structure, structure and functions of specific immunoglobulins, antibody diversity, plasma cell dyscrasias.

Unit-II

The complement system: Complement, pathways of complement activation, membrane attack pathway, biological consequences of complement activation, regulatory mechanisms.

The immune response system: Exposure to an antigenic substance, the lymphoid system, cells involved in the immune response, events in the induction of the immune response, intracellular events occurring during cell maturation, phases of the humoral immune response.

Unit-III

Immune regulation: Introduction, immunosuppression, tolerance, immunopotentiation.

Immunization: Introduction active immunization, passive immunization, experimental immunization procedures, adverse reactions of vaccines.

Immunological techniques: *In vitro* antigen- antibody reactions, procedures for direct observation and demonstration of reactions, complex serological procedures, assays of immune competence, identification of specific allergens in type I hypersensitive reactions, detection of immune complexes, production and use of monoclonal antibodies.

Immunologic mechanisms of tissue damage: Introduction, immediate hypersensitivity (typeI) reactions, cytotoxic (typeII) reactions, immune complex- mediated (typeIII) reactions, cell-mediated (type-IV) reactions: delayed hypersensitivity and cell –mediated cytotoxicity.

Unit-IV

Auto immune diseases: General considerations, representative auto immunodisorders.

Immunodeficiency disorder: Phagocytic cell defects, B-cell deficiency disorders, T-cell deficiency disorders, secondary immunodeficiency disorders combined B-cell and T-cell deficiency disorders, secondary immunodeficiency conditions, complement deficiencies.

Transplantation immunology: Introduction, histocompatibility gene complex, clinical transplantation immunology.

Tumor immunology: Neoplasms, tumor-associated antigens, immune response to tumor antigens, immunologic factors favouring tumor growth, immunotherapy.

Practical-2 (HC)

Objectives are:

- To study the DNA and RNA
- To perform immunological techniques.
- To learn cloning and screening of genes.

Course outcome the student will be able to

- Carry out isolation and anslysis of DNA from various sources (plant, animal and microbial)
- Understand the principles and methodology of various immunological techniques.
- Perform techniques such as restriction digestion, cloning, agarose gel electrophoresis and PCR .

Experiments

- Estimation of DNA by Diphenylamine (DPA) method.
- Estimation of RNA by orcinol method

- Isolation of DNA different samples: plant leaves, coconut endosperm, yeast, animal tissues
- Determination of purity and concentration of isolated DNA using spectrophotometer
- Isolation of plasmid DNA from *E. coli*
- Agarose gel electrophoresis of DNA
- Purification of DNA from gel
- Determination of RNAse activity
- Isolation of RNA
- Restriction digestion of plasmid and analysis
- DNA ligation
- Transformation and screening
- Production of recombinant protein
- Polymerase chain reaction
- Demonstration of realtime PCR and Next generation sequencing
- Preparation of antigen and antibody production.
- Purification of IgG.
- Slide agglutination test/ Blood grouping.
- Immunoprecipitation test- Ouchterlony double diffusion.
- Immunoaffinity purification of IgG.
- Immunofluorescence for localization of an antigen.
- ELISA for quantification of an antigen.
- Western blotting and detection.

Semester III

Plant Biotechnology (HC)

48 h

The objectives of this course are:

- To study the basics of Plant tissue culture, Micropropagation, Plant transformation and Genetic manipulation of plants.
- To understand the application of Plant tissue culture, commercial product development and IPR.

Course outcome

Upon Course completion, the student will:

- Understand the plant micropropagation, germplasm preservation, haploid production and direct gene transfer techniques.
- Understand the production of secondary metabolites from plants, molecular farming and mushroom cultivation.
- Understand the Plant Breeder's Rights, Labeling of GM crops and foods. Biodiversity, traditional knowledge, access and benefit sharing.

Unit-I: Techniques in plant tissue culture

Methods in Plant Tissue culture: Historical perspective, Scope and applications of plant tissue culture, Concept of cellular Totipotency, Role of phytoregulators in growth, tissue-specificity and development of plants. Establishment of cultures- Nutritional requirements for *in vitro* cultures, Media preparation, Sterilizing agents, Callus Induction, Somatic embryogenesis, Synthetic seeds production, Organogenesis.

Micropropagation: Propagation from shoot apical meristem, node cultures, stages of micropropagation and applications. **Germplasm preservation**: Plant germplasm storage by Cryopreservation, Cryotherapy, cryoprotectants, steps in cryopreservation, Gene banks, applications. **Haploid Production**: Methods of androgenic haploid cultures, Factors affecting haploid cultures, applications in plant breeding. **Protoplast Culture and Somatic Hybridization**: Protoplast isolation, purification and culture, protoplast fusion, somatic hybridization, applications of somatic hybrids and cybrids. **Somaclonal variation**- causes and applications

Unit-II: Genetic manipulation of plants

Plant transformation techniques: *Agrobacterium*-plant interaction, Ti and Ri plasmids, opines, *vir* genes, T-DNA transfer, disarmed Ti plasmid. *Agrobacterium*-mediated gene delivery- binary and co-integrated vectors, use of promoters and reporter genes; viral vectors.

Direct gene transfer methods- Particle bombardment, PEG-mediated, electroporation, screenable and selectable markers, selection of transformants.

Transgenic plants: Herbicide resistance, pest resistance, plant disease resistance, abiotic stress tolerance; male sterility, improvement of crop yield and nutritional quality. Biosafety regulations of transgenics.

Unit III: Applications of Plant Tissue culture

Secondary metabolite production: Major secondary metabolic pathways- Phenylpropanoid pathways, Shikimate pathway; Induction of bioactive secondary metabolites by plant tissue culture; Value addition via biotransformation; hairy root cultures for production of pharmaceuticals; Industrial production of food additives and fragrances; Bioreactor systems for mass cultivation of plant cells.

Molecular pharming: Concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds, edible vaccines.

Unit-IV: Commercial product development

Micro algal biotechnology: Microalgae, culture media, cultivation methods, Medicinal compound from marine flora and fauna, nutraceuticals, Cosmeceutical applications.

Single-Cell Proteins (SCP): Spirulina, Chlorella, Yeast as SCP; Production and process; Health benefits of SCP.

Agricultural products: Biopesticides, biofertilizers, Vermiculture.

Biofuels: Biofuel production; Ethanol, Biogas, Hydrogen and their applications.

Mushroom cultivation: Mushroom cultivation; important edible mushrooms, nutritive and medicinal value of edible mushrooms.

Intellectual Property Rights (IPR): IPRs and agricultural technology- implications for India. Plant Breeder's Rights. Labeling of GM crops and foods. Biodiversity, traditional knowledge, access and benefit sharing.

Animal Biotechnology (HC)

48h

The objectives of this course are:

- To culture animal cells, closning and selection, cell separation and characterization, culturing of speciliased cells and embryo culture.
- To understand the cell and tissue engineering, IVF and production of transgenic animals.

Course outcome

Upon Course completion, the student will:

- Be able to isolate mouse and chick embryos, isolation of clones and genetic variants, chromosome analysis and cytotoxicity assays.
- Be able to understand the mechanism involved in bone grafts, nerve grafts, Embryo transfer in Humans, Super ovulation and embryo transfer in farm animals.
- Be able to understand the gene transfer, The legal and socio-economic impact of biotechnology and Biosafety regulations.

Unit-I

Culture of animal cells: Advantages and limitations of tissue culture, aseptic handling, facilities required, media and cell lines. Primary culture: Isolation of mouse and chick embryos, human biopsies, methods for primary culture, nomenclature of cell lines, sub culture and propagation, immortalization of cell lines, cell line designation, selection of cell line and routine maintenance.

Cloning and Selection: Cloning protocol, stimulation of plating efficiency, suspension cloning, isolation of clones, isolation of genetic variants, interaction with substrate, selective inhibitors.

Unit-II

Cell separation and characterization: Density based, antibody based, magnetic and fluorescence based cell sorting. Characterization of cells based in morphology, chromosome analysis, DNA content, RNA and protein, enzyme activity, antigenic markers, cytotoxicity assays, cell quantitation, cell culture contamination: monitoring and eradication, cryopreservation.

Culturing of specialized cells: Epithelial, mesenchymal, neuro ectodermal, hematopoietic gonad and tumor cells, Lympocyte preparation, culture of amniocytes, fish cells, confocal microscopy. Stem cell culture and its applications

Organic and embryo culture: Choice of models, organ culture, histotypic culture, filter-well inserts, neuronal aggregates whole embryo culture eggs, chick and mammalian embryos.

Unit-III

Cell and Tissue engineering: Growth factors for *in situ* tissue regeneration, biomaterials in tissue engineering, approaches for tissue engineering of skin, bone grafts, nerve grafts. Haemoglobin-based blood substitutes, bio artificial or biohybrid organs. Limitations and possibilities of tissue engineering, 3D bioprinting.

***In vitro* fertilization and Embryo transfer:** *In vitro* fertilization in Humans, Embryo transfer in Humans, Super ovulation and embryo transfer in farm animals e.g: Cow.

Cloning of Animals: Methods and uses. Introduction, nuclear transfer for cloning, cloning from- embryonic cells, adult and fetal cells. Cloning from short-term cultured cells: cloning of sheep, monkeys, mice, pets, goats and pigs. Cloning from long-term cultured cells: Cloning of cows from aged animals. Cloning efficiency, cloning for production of transgenic animals, gene targeting for cloned transgenic animals, cloning for conservation, human cloning: ethical issues and risks.

Unit-IV

Transfection methods and transgenic animals: Gene transfer, transfection of fertilized eggs or embryos, unfertilized eggs, cultured mammalian cells, targeted gene transfer. Transgenic animals and applications: mice and other animals, sheep, pigs, goats, cows and fish.

The legal and socio-economic impact of biotechnology at national and international levels, public awareness.

Biosafety regulations- guidelines for research in transgenic animals, public awareness of the processes of producing transgenic organisms.

Bioprocess Technology (HC)

48h

The objectives of this course are:

- Screening and maintenance of industrially important microbes, downstream processing.
- To understand the production of microbial products, vitamins, enzymes, organic acids, amino acids, antibiotics and polymers and bioprocess in agro-industry.

Course outcome

Upon Course completion, the student will:

- Be able to isolate the industrially important microbes, their growth kinetics, upstream process, media formulation and optimization.
- Be able to understand the mechanism involved Separation of insoluble products and Microbial production and application of commercially important products.
- Be able to understand the catalysts in organic synthesis, Isolation and screening of bioagents for the production of biofertilizers, biopesticides and plant growth promotion and their mechanism of action.

Unit I

Basic principles: Isolation, screening and maintenance of industrially important microbes; microbial growth kinetics of industrially useful microorganisms; effect of nutrients; strain improvement for increased yield and other desirable characteristics.

Batch and continuous fermenters: chemostat systems, fed-batch operations; conventional fermentation; immobilized cell systems; fermentation economics; upstream processing:

media formulation and optimization; sterilization; aeration, agitation, pH; scale up and scale down; measurement and control of bioprocess parameters; transport phenomenon in bioprocess: scale up of bioreactors, mass transfer coefficient, heat transfer.

Unit II

Downstream processing:

Separation of insoluble products – separation of cells and foam; filtration (plate filters, rotary vacuum filter), centrifugation (continuous, basket and bowl centrifuge), Stokes law, sedimentation, flocculation; cell disruption (mechanical and non-mechanical methods); separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying (spray, drum, freeze driers); crystallization; storage and packaging.

Unit III

Microbial products: Microbial production and application of vitamins (C, B12, B2, B5, B8, provitamin A and D_2), enzymes (detergents, HFCS, textile, leather, cheese, juice production, wood pulp; analytical, diagnostic, therapeutic, biotransformation, catalysts in organic synthesis), organic acids (acetic, citric, gluconic, itaconic, lactic, kojic), amino acids (glutamic acid, lysine, tryptophan), polymers (polysaccharides – xanthan, curdlan, dextran, gellan, pullulan, chitin, glycan, scleroglucan; polyesters – PHB), antibiotics, ethanol, biosurfactants.

Unit IV

Bioprocess in agro-industry: Isolation and screening of bioagents for the production of biofertilizers, biopesticides and plant growth promotion; mechanism of action, mass cultivation, formulation and storage life; Bioprocess in sustainable agriculture (organic matter recycling, composting, Jeevamrutha).

Practical-3 (HC)

The objectives of this course are:

- The students will be exposed to screening and maintenance of industrially important microbes, downstream processing.
- The students will get to know the production of microbial products, vitamins, enzymes, organic acids, amino acids, antibiotics and polymers and bioprocess in agro-industry.

Course outcome

Upon Course completion, the student will:

- The students will be be able to have the hands-on experience to isolate the industrially important microbes, their growth kinetics, upstream process, media formulation and optimization.

- The students will be be able to get hands-on experience in understanding the mechanism involved Separation of insoluble products and Microbial production and application of commercially important products.
- The students will be exposed to understand the catalysts in organic synthesis, Isolation and screening of bioagents for the production of biofertilizers, biopesticides and plant growth promotion and their mechanism of action.

List of Experiments

Plant Biotechnology

- Preparation of plant tissue culture media
- Callus induction
- Induction of somatic embryogenesis
- Establishment of cell suspension cultures for plant secondary metabolite production
- Encapsulation of somatic embryos and production of synthetic seeds
- Organ cultures: Shoot tip, nodal, anther and leaf cultures
- Micropropagation technique – banana
- Protoplast isolation technique
- Secondary metabolite estimations: Colorimetry and TLC methods
- *Agrobacterium*-mediated genetic transformation
- GUS expression in transformed tissues

Animal Biotechnology

- Preparation of media, culture and maintenance of cell lines, trypsinization
- Culture of transformed cells
- MTT assay for cytotoxicity
- ^{3}H-Thymidine uptake assay for cell proliferation
- Cryopreservation and revival of cells
- Transient transfection assay using RSV β gal gene for transfer
- *In vitro* growth of blood vessels
- Lymphocyte preparation

Bioprocess Technology

- Immobilization of yeast by calcium alginate gel entrapment and assay for enzymes-invertase and catalase
- Screening of antibiotic producing microorganisms
- Study of alcohol fermentation- alcohol from different substrates-estimation of alcohol content
- Bioassay methods- Vitamins and amino acids
- Analysis of microbial quality of foods
- Study of fermenter (demonstration)

Paper Presentation: Presentation of recent Research Article published in the last two years which is appropriate in the various disciplines of Biotechnology from a peer reviewed Journal of an international repute.

Semester IV

Project work (HC)

Objectives are:

- To address a small research problem related to different aspects of Biotechnology.
- To design, perform and interpret the results of the research problem.

Course outcome the student will:

- Understand to review research papers for find out gap in the literature.
- Understand designing experiments based on the research problem.
- Understand compiling and analyzing of data.
- Be able to write a comprehensive project report/review.

Project work will be on defined research topic allotted to the students. The students will also have to present a research data paper published recently in peer reviewed journals preferably in the area of project work.

Softcore Papers

Cancer Biology (SC)

48 h

The objectives of this course are:

- To understand the basics of cancer biology, oncogensis and signal transduction.
- To understand the natural history of cancer development, current concepts in cancer therapy.

Course outcome

Upon Course completion, the student will:

- Be able to understand the mechanism of carcinogenesis, cancer initiation, promotion and progression, Cancer cell cycles, Tumor suppressor gene pathways, DNA methylation, epigenetic silencing of suppressor genes.
- Be able to understand the detection of oncogene abnormalities in clinical specimens, Cell: cell interactions, cell adhesion, angiogenesis, invasion and metastasis.
- Be able to understand the Strategies of anticancer gene therapy.

Unit-I

Cancer Biology: the basics

Introduction, historical perspective, classification, Carcinogenesis, cancer initiation, promotion and progression, Cancer cell cycles, Genomic instability, Apoptosis, Genes and proteins as players in apoptosis, DNA viruses/ cell immortalization.

Unit-II

Cancer Genes I: Oncogenes and signal transduction

Cellular proto-oncogenes, oncogene activation, Growth factors, growth factor receptors, signal transduction , Transcription, Transcription factors and cancer, Retroviral oncogenes, Tumor suppressor, Tumor suppressor gene pathways, DNA methylation, epigenetic silencing of suppressor genes.

Unit-III

Understanding Cancer as a Disease: natural history of cancer development

Free radicals, antioxidants and metabolic oxidative stress and cancer, Epidemiology of selected cancers, Gene rearrangements, detecting oncogene abnormalities in clinical specimens, Cell: cell interactions, cell adhesion, angiogenesis, invasion and metastasis, Antiangiogenic therapy of cancer.

Unit-IV

Current concepts in cancer therapy

Strategies of anticancer chemotherapy, Strategies of anticancer gene therapy/translating therapies from the laboratory to the clinic, Gene discovery in cancer research, cancer genome anatomy project , Cancer immunity and strategies of anticancer immunotherapy, stem cells and their applications in cancer therapy.

Food and Environmental Biotechnology (SC)

48 h

The objectives of this course are:

- To understand the fermentation of foods, milk, fish and food authentication.
- To understand the production of functional foods, designer foods, neutraceuticals, GM foods
- To understand the renewable and non-renewable energy resources, Bioremediation, phytoremediation process.

Course outcome

Upon Course completion, the student will:

- Be able to understand the production of tempeh, soy sauce, rice wine and anticancer compounds infoods.
- Be able to understand the Biochemical processing in the improvement of functional foods with targeted health benefits and increased nutrient value.
- Be able to understand the process of waste water management, conservation of biodiversity, pollution and its control.
- Be able to understand concepts and principles of bio/phyto- remediation.

Unit-I

Introduction to Food biotechnology, Fermented foods, milk-based products, fermented vegetables, fermented meats, fish, beverages, vinegar, mould fermentation - tempeh, soysauce, rice wine. Enzymatic processing of fruit juices; DNA-based methods for food authentication, comparative methods of toxicity testing in (novel) foods, application of generic technologies in food and nutritional sciences; anti-cancer components in foods.

Unit-II

Functional foods and Biotechnology: Biochemical processing in the improvement of functional foods with targeted health benefits and increased nutrient value; Pre- and Pro-biotics, single cell protein, single cell lipids. Manipulation of fruit ripening process. Food processing, principles and practices, food ingredients and processing aids from biotechnological processes, corn sweeteners, bacterial starter cultures, cold-adapted enzymes. Food spoilage, preservation, mycotoxins in food commodities. Genetically modified foods, designer foods, detection of GM foods, Nutraceuticals, Concept of food parks.

Unit-III

Introduction to Environment, Renewable and non-renewable resources, current status of biotechnology in environment protection.Waste water management: Bioreactors for waste-water treatment, treatment of industrial effluents-dairy, distillery, paper and sugar industries. Membrane-based waste water treatment. Pollution and its control, pollution indicators. Biodiversity and its conservation, Microbial ecology.

Unit -IV

Bioremediation: Concepts and principles, bioremediation using microbes, in situ and ex situ bioremediation, biosorption and bioaccumulation of heavy metals. Phytoremediation

Xenobiotics: Degradation capabilities of microorganisms with reference to toxicology, pesticides, herbicides, polyaromatic hydrocarbons.

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Biostatistics and Bioinformatics (SC)

48 h

Objectives are:

- To study the collection and representation of statistical data.
- To study the applications of various means of statistical analysis

- To study the basic concepts of bioinformatics.
- To study various data bases and servers involved.
- To study various bioinformatics tools.

Course outcome the student will:

- Understand the collection and graphical representation of data.
- Understand the sample size and hypothesis testing.
- Understand the various means of statistical analysis including t test, ANOVA, correlation and regression
- Understand the biological databases and related software employed to analyze DNA and protein sequences.
- Understand sequence analysis using various software.

Biostatistics

Unit I

Statistical concepts: Data structure, sampling methods, descriptive statistics - data collection, tabulation, graphical representation – histogram, frequency polygon, frequency curve, bar graphs etc.

Measures of central tendency: mean, median, mode

Measures of dispersion: Range, interquartile range, mean deviation, standard deviation, standard error, coefficient of variation, confidence limits.

Unit II

Types of distribution of data: Normal, Binomial, Poisson

Hypothesis testing: Z-test, t-test, ANOVA, multiple comparisons – LSD and DMRT, chi-square test; Regression and correlation; Non-parametric significance tests; Experimental designs- CRBD, RCBD, LSD, factorial; data transformation- arcsine, log, square-root.

Bioinformatics

Unit III

Bioinformatics- an overview, Definition and History, Applications of Bioinformatics.

Introduction to Genomics: Genome mapping, Genome sequencing, human Genome project.

Introduction to Proteomics: Tools and techniques in proteomics.

Sequence formats. Homology and similarity.

Introduction to Data mining, NCBI, EBI, DDBJ,

Database search software: ENTREZ, SRS, Expasy.

Protein Sequence Databases, UNIPROT, Structure Database: PDB.

Sequence Analysis: definition of sequence analysis, Introduction to Sequences, alignments and Dynamic Programming; Local alignment and Global alignment (algorithm and example), Pair wise Alignment, and significance of alignment, Tools of sequence alignment, Homology sequence search, Nucleotide Sequence Analysis, Protein Sequence Analysis, Parameters of Blast, BlastN, BlastP, Interpreting Blast Results.

Unit IV

Multiple sequence analysis, scoring pattern, exhaustive and heuristic algorithms; Parameters of CLUSTAL-W and CLUSTALX for multiple sequence alignment, interpretation; Phylogenetic analysis: methods and tools.

RASMOL Display Styles- Wire Frame, Ball and Stick, Space Fill, Ribbons, Cartoons.

Drug discovery: Introduction, drug discovery technologies, virtual high-throughput *in silico* screening, Target validation

EMBOSS Introduction to emboss Software package and its key features, other latest commercial softwares

Molecular Genetics (SC)

48 h

Objectives are:

- To study the genome organization in various organisms
- To study the molecular basis og mutation, recombination and repair
- To study the developmental biology of model organisms

Course outcome the student will:

- Understand the genome organization in prokaryotes, eukaryotes and viruses
- Understand the molecular mecahanism of transposition, mutation, recombination and repair
- Understand the microbial transformation, quantitative genetics
- Understand the anterioposterior axis specification in *Drosophila*.

Unit-I

Genomic organization: Prokaryotes, eukaryotes, viral genome-DNA & RNA viruses extrachromosomal genome-plasmids, mitochondria and chloroplast, C-value paradox, Repetitive DNA-satellite DNAs and interspersed repeated DNAs, LINES, SINES, Alu family.

Mobile genetic elements: discovery, insertion sequence in prokaryotes, complex transposons (Tn10, Tn5, Tn9 and Tn3 as examples), mechanisms, control. Transposable elements in eukaryotes- Maize, Drosophila and humans

Unit-II

Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, Molecular basis of mutations, insertional mutagenesis, site-specific mutagenesis

Recombination: Homologous and non-homologous recombination, Holliday model, site-specific recombination.

DNA Repair: Mechanism of genetic repair- direct repair, photoreactivation, excision repair, mismatch repair, post-replicative recombination repair, Repair of double-strand breaks, SOS repair.

Unit-III

Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.

Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.

Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.

Unit-IV

Genes and development: **Model systems for studying development**- ***Drosophila, Caenorhabditis, Arabidopsis.***

Genetic control of development in Drosophila: Anterioposterior axis specification, role of maternal genes, segmentation of larval body, gap genes, pair rule genes, homeotic genes, complex gene interaction in development, sequential gene action.

Floral meristems and floral development in *Arabidopsis,* ABC model.

Genomics and Proteomics (SC)

48h

Objectives are:

- To study the importance of Omics biology
- To study the various techniques in genomics
- To study the various techniques in proteomics

Course outcome the student will:

- Understand the genome organization and mapping
- Understand the various gene sequencing techniques
- Understand the techniques involved in gel based and gel-free proteomics.

Unit-I

Genome: Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast

Genome mapping: Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping.

Genome sequencing: Next generation sequencing, Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.

Unit-II

Comparative genomics: Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.

Functional genomics: Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics;

Unit –III

Introduction to proteomics: Proteome and nature of proteome, Proteins - amino acids, peptides and polypeptides, separation of proteins /peptides by single and two-dimensional gel electrophoresis and detection- staining and immunoblot.

Unit-IV

Structural and functional proteomics: Mass spectrometry – fundamentals, mass spectrometry ionization techniques, mass analyzers – MALDI-TOF, MS-MS, LC-MS-MS; In-gel digestion, PMF, Mass spectra analysis – search engines: Mascot, swiss-prot, protein prospector, identification, molecular weight, determination of peptide sequence, determination of post-translational modifications, peptide sequencing using tandem mass spectrometry, quantitative proteomics-iTRAQ, functional annotation of proteins, protein chips and functional proteomics; clinical and biomedical applications of proteomics

Cell Biology and Cellular Signaling (SC)

48 h

Objectives are:

- To study the basic components of a cell,
- To study various cellular processes.
- To study the signal transduction pathways

Course outcome the student will:

- Understand the detailed structure and function of a cell
- Understand the various cellular processes such as cell cycle, cel;lular transport etc
- Understand the various signaling cascades in regulation of cellular metabolism.
- Understand host parasite interaction.

Unit I

Dynamic organization of the cell

Ultra-structure of prokaryotic and eukaryotic cells; Universal features of cells; cell chemistry and biosynthesis: chemical organization of the cell; internal organization of the cell-cell membranes: structure of cell membranes - models, intracellular organelles: endoplasmic reticulum and Golgi apparatus; Mitochondria, chloroplast, Lysosomes. Nucleus - Internal organization, Nucleosomes, Chromatin- structure and function, cellular cytoskeleton.

Unit- II

Cellular processes

Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis: cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell motility and migration; cell death: different modes of cell death and their regulation.

Molecular mechanisms of membrane transport active, passive, facilitated. Types of vesicles - transport and their functions,

Unit III

Basics of Signal Transduction

Extra-cellular matrix components, Cell junctions, Cell adhesion molecules, Hormones and their receptors, Cell surface receptors as reception of extra-cellular signals, Types of cell signaling, Growth factors- EGFR, VEGF, PDGF and their Signaling, adapter proteins required for signal transmission; signaling through G-protein coupled receptors; Second messengers in signal transduction pathways: cAMP, cGMP, calcium ions ($Ca2^{+}$), and inositol triphosphate (IP_3) and ligand-gated ion channels; signaling through Receptor tyrosine kinases; neurotransmission and its regulation. Biochemistry of vision.

Unit-IV

Signal transduction pathways in animals: Phosphorylation cascades; MAP kinase, Intracellular signaling in Development and Disease, SAP/JNK, p38, Wnt signaling, Jak/Stat, Smad, TGF β Signaling, Cytoskeleton And Cell Signalling, MMPs And Cell Signalling, Cross talks among cytoplasmic components, NF-κB signaling from cytoplasm to nucleus.
The end point of signal transduction, gene transcription**:** Nuclear receptors and transcription factors in signaling.

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Host-parasite interaction: Bacterial and plant two-component signaling systems; bacterial chemotaxis and quorum sensing, Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, pathogen-induced signaling pathways in plants- ROS, Jasmonate, SA-mediated pathways, resistance genes.

Molecular Diagnostics (SC)

48h

The objectives of this course are:

- To understand the Conventional diagnostic techniques for the detection of plant pathogens.
- To understand the Genome resolution, detection and analysis
- To understand the scope of molecular diagnostics and molecular oncology tests.

Course outcome

Upon Course completion, the student will:

- Be able to understand the detection and identification of plant pathogens, Koch rules.
- Be able to understand the different types of PCR, microarray and MALDI-TOF-MS.
- Be able to understand the Tests for Inherited Disorders and Prenatal Diagnostics: Cystic Fibrosis.

Unit-I:

Introduction to Plant molecular diagnostics, Conventional diagnostic techniques for the detection of plant pathogens – fungi, bacteria and viruses, seed-borne pathogens, Koch rules, Direct detection and identification of pathogenic organisms. Culture based and GOTs,

Indirect detection of pathogenic organisms, Serology based detection – IF, ODD, ELISA, DIBA, ISEM. Automated identification methods.

Unit-II

Genome resolution, detection and analysis:

Different types of PCR: Real-time; Multiplex; FISH; RFLP; DGGE; SSCP; Nucleic acid sequencing: new generations of automated sequencers; Microarray chips; EST; SAGE; microarray data normalization & analysis; molecular markers: 16S rRNA typing; MALDI-TOF-MS; Metabolite profile for biomarker detection the tissues in various disorders by making using LCMS & NMR technological platforms.

Unit-III

Background and scope of molecular diagnostics, Current and emerging technologies, Nonamplified Probe-Based Assays, Cytogenetics and FISH, PCR and Other Amplification Technologies, Microarrays, DNA Methylation Assays, Infectious Disease Diagnostics: Human Immunodeficiency Virus, Hepatitis C Virus, Hepatitis B Virus, Molecular Tests for Blood Screening, Chlamydia and Gonorrhea, Human Papillomavirus and Cervical Cancer, Methicillin-Resistant Staphylococcus aureus, Genetic Testing: Tests for Inherited Disorders and Prenatal Diagnostics: Cystic Fibrosis, Prenatal Diagnosis, Ashkenazi Jewish Genetic Panel, Predicting Risk of Disease, Risk of Venous Thromboembolism

Unit -IV

Molecular Oncology Tests, Analysis of the Expression of Multiple Genes and Cancer Prognosis, Analysis of Lymph Nodes to Detect Metastasis of Breast Cancer, Screening for Colorectal Cancer: Stool-Based DNA Screening, Leukemias and Lymphomas, DNA Methylation Tests and Cancer, Predicting Risk of Developing Cancer. Personalized Medicine: Pharmacogenomics and Companion Diagnostics, Cytochrome P450 and Drug Metabolism, Targeted Cancer Therapies and Companion Diagnostics Tests, Testing for HER2/neu Overexpression in Breast Cancer, Testing for Epidermal Growth Factor Receptor (EGFR), UGT1A1 Genetic Variants, Pharmacogenetics and Response to Antiretroviral Therapy, Thiopurine Methyltransferase and Metabolism of Thiopurine Drugs

Natural Products and Drug Discovery (SC)

48 h

The objectives of this course are:

- To understand the use of natural products in traditional medicine, extraction and isolation of natural products.
- To understand the target identification and molecular modeling.
- To understand the lead optimization from the natural resources.

Course outcome

Upon Course completion, the student will:

- Be able to understand the herbal remedies and novel drug templates from natural products.

- Be able to understand the natural products for drug discovery from different sources.
- Be able to understand the Use of bioinformatics and data processing in identification of lead compounds.
- Be able to understand the identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity

Unit I

Prospects of Natural Products research in the 21st Century: Introduction, use of natural products in traditional medicines, Marine natural products, Use of herbal remedies and the potential of drug development from natural products and novel drug templates: paclitaxel, podophyllotoxin, artimisinin etc.

Recent development in the research on naturally occurring polyphenolic compounds: - Introduction, biosynthetic pathway, isolation and characterization, biological and pharmacological activities of different class of phytoconstituents - alkaloids, flavonoids, terpenoids, glycosides, steroids, saponins, (Antioxidant activity, cyto-toxic activity, anticancer and anti-microbial activity etc).

Unit II

Natural product drug discovery from different sources (marine, microbial, mineral etc): Introduction, recent developments, applications.

Extraction and Isolation techniques: Introduction, Principle and Applications of different extraction & isolation methods viz Soxhlet extraction, microwave extraction, supercritical fluid extraction, solid phase extraction,Column chromatography, Flash chromatography.

Unit III

Target identification and molecular modeling: Identification of target or drug leads associated with a particular disease by different techniques including combinations of molecular modeling, combinatorial libraries and high-throughput screening (HTS); Use of bioinformatics and data processing in identification of lead compounds; Rational drug design, Modelling drug/receptor interactions with the emphasis on molecular mechanisms, molecular dynamics simulations and homology modelling; Conformational sampling, macromolecular folding, structural bioinformatics, receptor-based and ligand-based design and docking methods, in silico screening of libraries, semi-empirical and ab-initio methods, QSAR methods, molecular diversity, design of combinatorial libraries of drug-like molecules, macromolecular and chemical databases.

Unit IV

Lead optimization: Identification of relevant groups on a molecule that interact with a receptor and are responsible for biological activity; Understanding structure activity relationship; Structure modification to increase potency and therapeutic index; Concept of quantitative drug design using Quantitative structure–activity relationship models (QSAR models); Bioanalytical assay development in support of *in vitro* and *in vivo* studies (LC/MS/MS, GC/MS and ELISA).

Preclinical development: Principles of drug absorption, drug metabolism and distribution - intestinal absorption, metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies, Principles of toxicology, Experimental design for preclinical and clinical PK/PD/TK studies, Selection of animal model; Regulatory guidelines for preclinical PK/PD/TK studies; Scope of GLP, SOP for conduct of clinical & non clinical

testing, control on animal house, report preparation and documentation. Integration of non-clinical and preclinical data to aid design of clinical studies.

Nanobiotechnology (SC)

48 h

The objectives of this course are:

- To understand the fundamentals of nanoscale materials, Synthesis and characterization of different nanomaterials.
- To understand the Basic structure of Nanoparticles and bionanocomposites.
- To understand the sustainable Nanobiotechnology.

Course outcome

Upon Course completion, the student will:

- Be able to understand the different formats of nanomaterials, Cellular nanostructure and Bio-inspired Nanostructures.
- Be able to understand the Synthesis and characterization of nanomaterials.
- Be able to understand the Applications of nanobiotechnology in Plant and animal cell cultures.
- Be able to understand the toxicity testing and Mechanism of nano-size particle toxicity.

Unit I

Introduction and Fundamentals of nanobiotechnology

Concepts, historical perspective; Nanoscale materials: Definition and properties; Different formats of nanomaterial and applications; Cellular nanostructure; nanopores; Biomolecular motors; Bio-inspired Nanostructures, Quantum dots.

Synthesis and characterization of different nanomaterials: Synthesis of nanomaterials from plant, microbial and animal cell sources. Characterization of nanomaterials using Optical Microscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, Scanning Tunneling Microscopy, Optical Absorption and Emission Spectroscopy, Thermogravimetric Analysis, Differential Scanning Calorimetry, Thermomechanical Analysis, X-Ray, neutron diffraction.

Applications of nanobiotechnology in Plant and animal cell cultures, stem cell culture and artificial organ synthesis.

Unit II

Nano-particles

Concepts of Nanoparticles: Basic structure of Nanoparticles- Kinetics in nano-structured Materials- Zero dimensional, size and shape of nanoparticles; one-dimensional and two-dimensional nanostructures; clusters of metals and semiconductors, bionano-particles.

Bionancomposites: Nano-particles and Microorganisms; Microbial Synthesis of Nano-materials; Biological methods for synthesis of nano-emulsions using bacteria, fungi and Actinomycetes; Plant-based nanoparticle synthesis; Nano-composite biomaterials – Fibres, devices and structures, Nano Bio-systems.

Unit III

Applications of Nanobiotechnology

Applications of Nanomedicine: Nanotechnology in diagnostic applications, materials used in Diagnostics and Therapeutics. Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nano-scaffolds in synthesis, applications of nano-biocatalysis in the production of drugs and drug intermediates.

Nano-films: Thin films; Colloidal nanostructures; Self-assembly, Nanovesicles; Nanospheres; nanocapsules and their characterization.

Nanoparticles for drug delivery: Strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Nanoparticles for diagnostics and imaging: Concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

Applications in Agriculture: Biogenic nanomaterials and their role in soil, water quality and plant protection; Smart nanoscale systems for targeted delivery of fertilizers, pesticides (nanocides); Nanoremediation.

Unit IV

Sustainable bionanotechnology: Application of industrial ecology to nanotechnology, Fate of nanomaterials in environment, environmental life cycle of nano-materials, environmental and health impacts of nano materials, Nano-materials in future - implications.

Toxicity and safety of nanomaterials: Introduction to Safety of nanomaterials; Concept of Nanotoxicology – Models and assays for nanotoxicity assessment; Laboratory rodent studies.

Ecotoxicologic studies: Methodology for Nanotoxicology - toxicity testing; Mechanism of nano-size particle toxicity; Reactive oxygen species mechanisms of NSP toxicity; Interactions between nanoparticles and living organisms.

Stem Cells And Regenerative Medicine (SC)

48 h

The objectives of this course are:

- To understand the basic and translational research of stem cells.
- To understand the Tissue engineering principles and perspectives, Stem cells in retina and inner ear.
- To understand the therapeutic uses of stem cells.

Course outcome

Upon Course completion, the student will:

- Be able to understand the Differentiation in early development of stem cells, and Pluripotent stem cells.
- Be able to understand the Isolation and characterization of amniotic fluid-derived stem cells.
- Be able to understand the Sources and characterization of kidney stem cells. Stem cells in liver, pancreas and intestine.
- Be able to understand the Current stem cell-based therapeutic approaches. Regeneration of epidermis, Epidermal stem cells; Stem cells in burned and skin ulcers

Unit I: Introduction to Stem Cells

Overview of basic and translational research of stem cells. Differentiation in early development, Preimplantation development; From implantation to gastrulation.

Pluripotent stem cells I: Rodent embryonic stem cells – Origin, properties, self-renewal pathways, application. Human embryonic stem cells- Derivation and maintenance, self-renewal pathways. Induced pluripotent stem cells- Generation, Characterization, Induced pluripotency-the underlying mechanism. Primordial and embryonic germ cells- Origin, Properties, Derivation and maintenance.

Stem cells: Molecular and cellular basis of organ development

Unit II

Tissue engineering principles and perspectives; Limitations and hurdles of using embryonic stem cells in tissue engineering; Amniotic fluid and amniocentesis; Isolation and characterization of amniotic fluid-derived stem cells. New technologies for genetic modification in stem cells, CRISPR/Cas9, TALENs/ZFN. Neurogenesis and neural stem cells I- Establishment of neural tissue, Molecular basis of neural induction. Neurogenesis and neural stem cells II- Neural stem cells in brain; Pluripotent stem cell-derived neural stem cells Hematopoietic stem cells- Embryonic hematopoiesis; Hematopoietic stem cell niche; Embryonic stem cell-derived Hematopoietic stem cells. Cord blood hematopoietic stem cells, Cord blood transplantation; Characteristics, Genomics and proteomics of cord blood stem cells

Unit III

Stem cells in retina and inner ear- Sources and Properties

Skin organization, Skin stem cells, bulge as a residence of skin stem cells, Cell signaling in skin stem cells. Skeletal muscle stem cells- Sources, Intrinsic and extrinsic regulation

Stem cells in kidney-Anatomy of kidney development, Sources and characterization of kidney stem cells. Stem cells in liver, pancreas and intestine- Organization of adult liver and pancreas, Liver/Pancreatic stem cells, Intestinal stem cells. iPSCs for disease modeling; Models of nuerological diseases, hematopoietic disorders, cardiovascular conditions, metabolic disorders. Mesenchymal stem cells- Location, isolation and culture; tissue-engineering.

Unit IV: Therapeutic uses of stem cells

Stem cells to treat diabetes and liver disease, β-cell replacement therapy; Sources of insulin-producing cells; Hepatocyte transplantation; Challenges and future directions

Cancer stem cell theory – Isolation and characterization of cancer stem cells; Implications for cancer treatment: Stem cells to treat heart disease, Distribution of stem cells in heart; Preclinical studies. Orthopedic applications of stem cells, Biology of musculoskeletal tissues; Tissue engineering strategies for bone and cartilage defects. Neural stem cells for central nervous system repair, Therapeutic potential of neural stem cells; Cell replacement using neural stem cells. Stem cells for the treatment of muscular dystrophy, Celluar environment of a dystrophic muscle; Myogenic stem cells from embryonic stem cells and inducible pluripotent stem cells;

Current stem cell-based therapeutic approaches. Regeneration of epidermis, Epidermal stem cells; Stem cells in burned and skin ulcers

Regulatory aspects for stem cell research; Regulation of use of human embryonic stem cells.

Molecular Plant Pathology (SC)

48 h

The objectives of this course are:

- To understand the fundamentals of plant diseases, significance of plant diseases, disease triangle.
- To understand the Genetics of plant diseases and resistance
- To understand the Application of molecular biology to conventional disease control strategies.

Course outcome

Upon Course completion, the student will:

- Be able to understand the concept of plant disease, the causal agents, the significance of plant diseases, the control of plant diseases.
- Be able to understand the communication between bacteria, plant penetration, attachment, stimulation gene expression.
- Be able to understand the Genes and diseases, Mechanism of variability, and Gene-for-gene resistance
- Be able to understand the breeding for resistance, MAS, the use of tissue culture in plant breeding, and identification of novel resistance gene specificities,

Unit I

The fundamentals of plant pathology: The concept of plant disease, the causal agents, the significance of plant diseases, the control of plant diseases, molecular biology in plant pathology.

Fungal and oomycete diseases: establishing infection – dispersal spores, finding a suitable host, spore attachment, germination process, penetration, germ-tube elongation, induction appressoria, cell-wall degrading enzymes. Development of disease – Basic concepts of necrotrophy and biotrophy, host barriers, the role of toxins and enzymes, biotrophy, prevention of leaf senescence.

Unit II

Bacterial, viral and nematode diseases: communication between bacteria, plant penetration, attachment, stimulation gene expression, cell wall degrading enzymes, toxins, hormones, extracellular polysaccharides, determinants of host specificity. Plant viruses: Structure and replication, infection, translocation and replication, types of viruses, viroids, other sub-viral entities, Prokaryotic and Plant viruses. Important nematode diseases of plants.

Unit III

Genetics of plant diseases and resistance: Genes and diseases, Mechanism of variability, stages of variation in pathogens, Types of plant disease resistance to pathogens. Defence mechanism of plants, Pre-existing, structural, chemical and induced biochemical defences. Resistance genes: Gene-for-gene resistance, features of cloned resistance genes, R gene

specificity. Signalling in plant disease resistance mechanisms: Genetic analyses, MAP kinases, ion fluxes and calcium homeostasis, The oxidative burst, Nitric oxide, (p)ppGpp signaling, low-molecular weight signaling molecules

Unit IV

Application of molecular biology to conventional disease control strategies: Breeding for resistance, the use of tissue culture in plant breeding, marker-assisted breeding, identification of novel resistance gene specificities, the use of chemicals for disease control, biological control-PGPR and PGPF. Transgenic approaches for crop protection- Bt cotton and brinjal.

Bioentrepreneurship (SC)

48 h

The objectives of this course are:

- To understand the Innovation and entrepreneurship in bio-business, bio-markets.
- To understand the financing and accounting in bio-business.
- To understand the Management of technology transfer.

Course outcome

Upon Course completion, the student will:

- Be able to understand the types of bio-industries and competitive dynamics between the sub-industries of the bio-sector.
- Be able to understand the Pricing strategy, Challenges in marketing in bio business.
- Be able to understand the Business feasibility study, financial management and Collaborations & partnership.
- Be able to understand the knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures.

Unit I

Innovation and entrepreneurship in bio-business

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs.* Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME,

DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Unit II

Bio markets - business strategy and marketing

Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

Unit III

Finance and accounting

Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

Unit IV

Technology management

Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

Seed Health and Diagnostics (SC)

48 h

The objectives of this course are:

- To understand the seed biology and Chemical composition of seeds.
- To understand the process of seed production and processing.
- To understand the seed quality control and seed health and development of seed industry.

Course outcome

Upon Course completion, the student will:

- Be able to understand the Embryogenesis and seed development, Orthodox and recalcitrant seeds, seed dormancy.
- Be able to understand the Seed legislation, seed certification standards.
- Be able to understand the Designated plant diseases, tolerance, seed health and trade.

- Be able to understand the Seed health testing procedures for fungi, bacteria, viruses, nematodes.

Unit-I: Introduction

Seed Biology: Floral biology, mode of reproduction; Embryogenesis and seed development; Seed structure of monocots and dicots; Chemical composition of seeds; Orthodox and recalcitrant seeds, seed dormancy; Apomixis, parthenocarpy, polyembryony; Somatic embryogenesis and synthetic seeds.

Development of Seed Industry: Agricultural situation in India; impact of green revolution; cropping systems; International cooperation – ISTA, OECD, UPOV, AOSA, APSA, CGIAR and other organizations.

Seed Production: Introduction to crop breeding methods; Variety testing, release and certification; Different classes of seeds and their maintenance; Seed production requirements and planning; Male sterility; Clonal propagation; Transgenic seeds. Disease tolerance screening.

Seed drying, processing, storage and marketing: Seed drying principles and methods; Seed treatment, safe storage seeds and marketing strategies.

Unit-II: Seed Quality Control

Importance of seed quality: Seed legislation - Seed act 1965, seed rules 1969 and new seed act 2004.

Seed certification - History, concept, organization, phases and seed certification standards; Field inspection principles and methods; Determination of seed quality - seed sampling, physical purity, moisture, germination, genetic purity; Seed certification agencies; Testing of transgenic seeds.

Unit-III: Seed Health

Importance: Designated plant diseases, tolerance, seed health and trade, Pest-free areas (PFA), Pest Risk Analysis (PRA).

Significance of seed health - important seed borne diseases of cereals, pulses, oil seeds, fiber and vegetable crops; Mechanism of seed transmission and disease cycle.

Management of seed-borne diseases: Quarantine and phytosanitary certificates, Physical and chemical control, biological control, cross protection.

Storage fungi and insects: Causes and indices of seed deterioration during storage, fumigation.

Mycotoxins – Important mycotoxins, factors influencing mycotoxin production, harmful effects, detection.

Unit-IV:

Diagnostics - Seed health testing procedures for **Fungi** – symptoms, dry seed examination, incubation tests, embryo extraction technique, seedling symptom test; **Bacteria** – symptoms, colony appearance, liquid assay, selective and semi-selective media, staining techniques, biochemical & physiological tests, pathogenicity tests, immune-fluorescent technique, Biolog; V**iruses –** symptoms**,** seed examination, growing-on test, indicator plant test, electron microscopy, ISEM, ELISA, DIBA, IC-RT-PCR; **Nematodes** – Extraction and identification.

Application of serological methods – monoclonal and polyclonal antibodies, conventional serological techniques – precipitin tests, agglutination tests, ELISA, DIBA, and nucleic acid based techniques; Multiplex ELISA and PCR, Application of Real Time (RT)-PCR; FTA technology. Sequence databases of seed-borne pathogens. Gene targets and primer designing.

Open Elective

Biotechnology and its Applications

48 h

Objectives are:

- To study the basic aspects of recombinant DNA technology.
- To study overview of microbial, food and environmental biotechnology.
- To study the basics of plant and animal biotechnology.

Course outcome the student will:

- Have a bacis understanding of application of recombinant DNA technology
- Understand application of biotechnology in food industries and overcoming environmental problems.
- Understand the applications of plant and animal biotechnology .

Unit I

Introduction to biotechnology. Principles of biotechnology, classification.

Recombinant DNA Technology

Introduction, outline of genetic engineering procedure, restriction endonucleases, cloning & expression vectors- plasmids, cloning in plasmid, transformation and detection of transformants- lacZ, genomic and cDNA libraries, gene analysis techniques-hybridization: Southern, Northern, Western, *in situ*, Polymerase chain reaction.

Unit II

Microbial and food and environmental Biotechnology

Basics of fermentation technology: Types of microbial culture- batch, continuous and fed-batch. Microbial production: Use of microbes in production of vitamins, enzymes, organic acids, amino acids, polysaccharides, flavors, sweeteners, proteins and antibiotics.

Fermented food products- yogurt, cheese, tempeh, sauerkraut; beverages- wine and beer. Pre- and Pro-biotics, single cell proteins, Genetically modified foods, designer foods.

Current status of biotechnology in environment. Bioconservation, biofuels, gasohol, biogas.

Bioremediation: Concepts and principles, bioremediation using microbes, *in situ* and *ex situ* bioremediation, biosorption and bioaccumulation of heavy metals.

Unit III

Plant Biotechnology

Landmarks in Plant tissue culture. Types of cultures- embryo, organ, callus and cell cultures, Somatic embryogenesis, Haploid Production, Androgenesis, Protoplast culture and somatic hybridization. Micropropagation- Methods and stages, applications. Synthetic seeds, somaclonal variation. Production of secondary metabolites by plant cells, Biotransformation.

Plant transformation techniques: Direct and indirect methods of gene transfer in plants. Transgenic plants and crop improvement- herbicide tolerance, disease resistance, abiotic stress tolerance, delayed ripening, improvement of nutritional quality, molecular pharming.

Unit IV

Animal Biotechnology

Basics of animal cell culture techniques, cell lines, physical conditions for culturing animal cells, equipments required, scale-up of culture methods.

Application of animal cell culture- Hybridomas, production of therapeutic antibodies, stem cell technology, cell and tissue engineering.

Genetic engineering of animals: Methods for gene transfer in animals, microinjection, nuclear transplantation, retrovirus-mediated gene transfer, gene knockdown techniques. Transgenic-animals- sheep, pigs, cattle, chickens; applications of transgenic animals.

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