

## Semester wise break up of the course and marks M.Sc. Biotechnology

SEMESTER-1	Theory		Internal Assessment	Total	Semester total
1. Cell Biology	40	+	10	50	
2. Biochemistry	40	+	10	50	
3. Biophysical techniques	40	+	10	50	
4. Bioinformatics and Biostatistics	40	+	10	50	
5. Practical (1)	90			90	
6. Seminar	10			10	300
<b>SEMESTER-2</b>					
1. Molecular Biology	40	+	10	50	
2. Microbiology	40	+	10	50	
3. Molecular Immunology	40	+	10	50	
4. Enzyme technology	40	+	10	50	
5. Practical (1)	90			90	
6. Seminar	10			10	300
(After completion of second semester, the students may take up summer training program linked to their project.)					
<b>SEMESTER-3</b>					
1. Genetic engineering and RDT	40	+	10	50	
2. Bioprocess and Industrial Biotechnology	40	+	10	50	
3. Animal cell science and technology	40	+	10	50	
4.a. Plant Biotechnology	40	+	10	50	
OR 4.b. Agricultural Biotechnology					
(The student has to opt one---4b. for Ag. Biotech)					
5. Practical (1)	75			75	
6. Summer training report	25			25	300
<b>SEMESTER-4</b>					
1. Environmental Biotechnology	40	+	10	50	
2. Medical Biotechnology (optional)*	40	+	10	50	
or					
3. Aquatic Biotechnology (optional)*					
or					
4. Pharmaceutical Biotechnology (optional)*					
5. Practical (1)	75			75	
6. Project (Thesis + presentation & viva)	75	+25	+25	125	300
(* One optional is mandatory)					
				Course total :	1200

# **FIRST SEMESTER**

## **Paper-1. CELL BIOLOGY**

### **UNIT-I**

Diversity of cell size, type and shape, Cell theory. Structure of Prokaryotic and Eukaryotic cells - Isolation and growth of cells. Cell as a unit of living organisms – Cellular organelles: Plasma membrane, cell wall, their structural organization; Mitochondria, Chloroplast; Nucleus and other organelles and their organization, Nuclear Pore complex. Organization of cytoskeleton; cell microtubules, micro filament and intermediate filaments, Cell motility - cilia, flagella of eukaryotes and prokaryotes.

### **UNIT-II**

Chromatin structure; Organization of nucleosome and chromosome., Organellar genome, Molecular aspects of cell division and cell cycle; Cell cycle - molecular events and model system, cell cycle regulation.

### **UNIT-III**

Structure and Organisation of membranes, Glycoconjugates & Proteins in membrane system, Transport of nutrients, ions and macromolecules across membranes, Passive and active transport, Na<sup>+</sup>/K<sup>+</sup> pump. Protein Localization Synthesis of secretory and membrane proteins, Import into nucleus, mitochondria, chloroplast and peroxisomes, Receptor mediated endocytosis.

### **UNIT-IV**

Cellular responses to environmental signals in bacteria, plants and animals - mechanisms of signal transduction; Endocrine, Exocrine & Synaptic signaling, Surface and intracellular receptors, G Proteins & generation of secondary messengers, mode of action of cAMP & ca<sup>++</sup> Calmodulin. Cellular basis of differentiation and development - gametogenesis and fertilization, Development in Drosophila and Arabidopsis; Spatial and temporal regulation of Gene Expression.

### **UNIT-V**

Biology of cancer. Oncogenes and Tumor Suppressor Genes, Viral and cellular oncogenes, tumor suppressor genes from humans, Structure, function and mechanism of action of pRB and p53 tumor suppressor proteins. Apoptosis and necrosis.

## **Paper-2. BIOCHEMISTRY**

### **UNIT-I**

The molecular logic of life; Buffering in biological Systems; (Chemical foundations of Biology - pH, pK, acids, bases, buffers, Handerson-Hasselbatch equation, weak bonds (Ionic, Hydrogen, Hydrophobic, Vanderwaal interactions), covalent Bonds, Water as an universal solvent.

### **UNIT-II**

Biomolecules; Structure of Carbohydrates, Polysaccharides, Glycoproteins and Peptidoglycans. Lipids- structure and biological role. Nucleic acid- Structure & Chemistry, Amino acids and peptides; Proteins – classification, 3-D structure and Functional diversity, end group analysis, Protein sequencing, peptide synthesis, hierarchy in structure, Ramachandran plot. Classes of organic compounds and functional groups - atomic and molecular Dimensions, space filling and ball and stick models.

### **UNIT-III**

Bioenergetics; Thermodynamic laws, applications of free energy functions; ATP as the energy currency in biochemical systems; Energy rich bonds, coupled reactions, group transfer. Biological oxidation-reduction reactions; Electron transport and Oxidative Phosphorylation.

### **UNIT-IV**

Metabolism: Basic concepts glycolysis and TCA cycle,, gluconeogenesis and the pentose phosphate pathway; Glycogen Breakdown & Synthesis, fatty acid metabolism; Amino acid oxidation, Carbohydrate biosynthesis. Lipid biosynthesis; Phospholipid and Sterol synthesis. *De novo* synthesis and salvage pathways in nucleotide metabolism, Amino acid biosynthesis,. Integration of metabolism & concept of metabolic regulations.

### **UNIT-V**

Metabolic adaptation, metabolic changes associated with plant development and senescence and its regulation. Metabolic disorders, Hormonal imbalance, Drug metabolism, drug detoxification. General principles of intermediary metabolism and regulation of pathways. Vitamins and hormones: chemistry and physiological role. Photosynthesis- Site of Photosynthesis, Induction Electron transfer by chlorophyll, Molecular mechanism of Photosystem I & II, Membrane transport across the thylakoid membrane, Brief account of Xanthophyll, Carotenoid, Light Harvesting complex, antennary complex.

## **Paper-3. BIOPHYSICAL TECHNIQUES**

### **UNIT-I**

Micrometry, Colony counting, Microtomy and Principles and techniques of Microscopy; Magnification and resolution parameters of light, fluorescent phase contrast scanning, transmission electron microscopy, tunneling microscopy and Inverted microscope. Laboratory safety guidelines. Centrifugation – Basic principles of sedimentation, types of centrifuges, ultracentrifugation, differential, rate zonal, and isopycnic separations.

### **UNIT-II**

Principle & applications of pH meter, spectroscopy UV- Vis, colorimetry, spectro fluorimetry, CD&ORD, atomic Spectroscopy, infrared spectroscopy, Raman scattering, FT-IR, NMR, Mass Spectrometry (MS): Electron spin resonance Spectrometry (ESR), X-ray Crystallography.

### **UNIT-III**

Chromatographic techniques, Paper chromatography, partition chromatography, column chromatography, thin layer chromatography, Gas Chromatography, ion exchange, affinity chromatography, HPLC, HPTLC, FPLC.

### **UNIT-IV**

Electrophoresis: Capillary, agarose SDS & Native PAGE, pulse field, Immuno-electrophoresis, paper electrophoresis, Isoelectric focusing. PCR & Thermal cyclers, Nucleic acid hybridization: Southern & Northern blotting, Western blotting, Autoradiography, Organellar separation and Flow-cytometry.

### **UNIT-V**

Radio isotope technology: Radiotracer technology principle and applications Radiochemical methods: radioactivity, measurement of radioactivity, photographic emulsion, ionization chamber, scintillation counter, Geiger Muller counter, autoradiography.

## **Paper-4. BIOINFORMATICS AND BIOSTATISTICS**

### **UNIT-I**

Introduction to computers, Computer fundamentals (Hardware & Software), Input, Output devices and Storage devices, Web Browsers , Search Engines ,Flow charts, Methods and types of networks, Intra and Internet, Introduction to MS-office, graphic devices. Introduction to LINUX, O.S

### **UNIT-II**

Introduction to Bioinformatics, Scope and application of Bioinformatics, NCBI Data model, DNA and Protein Sequence database, Motif analysis, structural database, Structural Viewers (RasMol, RasTop, Cn3D, CSHF Chimera, Swiss PDB Viewer, PyMOL), Sequence submission to database, Literature database (PubMed, Biomed Central, Medline), Internet and biologist.

### **UNIT-III**

Retrieval tools (Entrez, DBGET, SRS) , Sequence alignment (Local, Global, Multiple), Sequence alignment algorithm: Dot matrix, Needleman & Wunsch, Smith-Waterman algorithm, Substitution matrix (PAM, BLOSUM), GOLD, KEGG ,ExPasy, PIR, Sequence analysis using online tools and GCG, ORF's (Open reading frames).

### **UNIT-IV**

ACeDB, Practical aspects of multiple sequence alignment (Clustalw, Clustalx), Predictive methods using protein sequence, Hidden Markoves Model, Theoretical prediction of 2D & 3D structure of protein., Docking, Online study and shot-gun method sequencing of *E.Coli* ,*D.Melanogaster*, Human genome, Mice genome, *A. Thaliana* genome ,Rice genome DNA Chips and their replications.

### **UNIT-V**

Introduction to Biostatistics, terminology and symbols, applications of statistics in biological research, collection and representation of data, measures of central tendency(Mean, Median, Mode), Coefficient of variation, Standard Deviation, Analysis of variation (ANOVA), measures of dispersion, distribution patterns(Binomial, Poisson & normal), tests of significance('t' test, 'f' test & chi-square test), probability, correlation and regression analysis, Introduction to statistical softwares and handling.

**Practical  
Seminar**

## **SECOND SEMESTER**

### **Paper-1.MOLECULAR BIOLOGY**

#### **UNIT-I**

Introduction to Molecular Biology: Structure and organization of genome. Law of DNA constancy, Cot curve c-value paradox, DNA renaturation kinetics, Determination of T<sub>m</sub> value.

#### **UNIT-II**

DNA as genetic material, DNA Replication - Prokaryotic and eukaryotic DNA, Molecular Mechanisms of DNA replication, Enzymes and accessory Proteins involved in DNA replication. DNA Repair and Recombination, Homologous Recombination, Holliday junction, FLP/FRT and Cre/Lox recombination. RecA and recombinases.

### **UNIT-III**

Transcription- Prokaryotic transcription, Eukaryotic transcription, RNA polymerase, General and specific transcription factors, transcription signals, promoter sites, rho and sigma factor, Regulatory elements and mechanisms of transcription regulation, Transcriptional and post-transcriptional modification. Reverse transcriptase, RNA processing; Modifications in RNA: 5'-Cap formation, Transcription termination, 3'-end processing and polyadenylation, Splicing; Ribonucleoproteins, RNA Editing, Nuclear export of mRNA and stability.

### **UNIT-IV**

Translation-Prokaryotic and eukaryotic translation, the translation machinery, Mechanisms of initiation, elongation and termination, Regulation of translation, co- and post-translational modifications of proteins. Genetic code: Properties, codon usage patterns and codon bias (Wobble Hypothesis). Regulation of Gene expression in Prokaryotes and Eukaryotes: Operon concept (E. coli Lac operon, trp operon, Ara operon), DNA methylation, Heterochromatinisation, Environmental regulation of gene expression.

### **UNIT-V**

Nucleic acid sequencing- Introduction and landmarks in DNA sequencing, Maxam Gilbert method, Sanger's method, Automated DNA sequencing, Pyro sequencing, 454 Nextgen sequencing, Whole genome sequencing. Antisense and Ribozyme Technology- Molecular mechanism of antisense molecules, Biochemistry of ribozyme; hammer- head, hairpin and other ribozymes, strategies for designing ribozymes, Applications of antisense and ribozyme technologies.

## **Paper-2. MICROBIOLOGY**

### **UNIT-I**

Discovery of the microbial world, Controversy over spontaneous generation, golden age of Microbiology, scope of microbiology in biotechnology. Classification of microorganisms: (Bacteria, Virus). Prokaryotic Cells: Structure-function Cell walls-of eubacteria (peptidoglycan) and related molecules; Outer-membrane of Gram- negative bacteria; Cell wall and cell membrane synthesis; Flagella and motility, Cell inclusions like endospores, gas vesicles.

### **UNIT-II**

Microorganisms in their natural habitat: Atmosphere, Hydrosphere, Lithosphere & Extreme habitats. Microbial interaction (Symbiotic and asymbiotic Nitrogen fixation) Bacteria & viruses as pathogens in aquaculture. Microbial media, Development of pure culture methods, Enrichment culture methods, pure culture techniques; Theory and practice of sterilization; Principles of microbial nutrition, Construction of culture media, Enrichment culture techniques for isolation of chemoautotrophs, chemoheterotrophs and photosynthetic microorganisms.

### **UNIT-III**

Microbial Growth - Mathematical expression of growth, growth curve, Measurement of growth and growth yields; Synchronous growth; Continuous culture, Growth as affected by environmental factors like temperature, acidity, alkalinity, water availability and oxygen; Culture collection and maintenance of cultures.

### **UNIT-IV**

Microbial Diseases Disease reservoirs; Epidemiological terminologies; Infectious disease transmission; Respiratory infections caused by bacteria and viruses; Tuberculosis; Sexually transmitted diseases including AIDS; Diseases transmitted by animals (rabies, plague), Food and water borne diseases; Host-Parasite Relationships. Chemotherapy/Antibiotics Antimicrobial agents,

Sulfa drugs; Antibiotics: Pencillins and Cephalosporins; Broad- spectrum antibiotics; Antibiotics from prokaryotes, Antifungal antibiotics; Mode of action; Resistance to antibiotics.

#### **UNIT-V**

Bacterial Mapping strategies: Transformation, Conjugation, Transduction, Recombination, Plasmids and Transposable Elements: Plasmid DNA and its transfer, plasmid replication, structure of transposable elements and its transcription. Mutation: Types of mutation, biochemical basis of mutations, mutagenesis. Viruses: Structure, isolation culture and purification of viruses, Viroids & prions, RNA & DNA viruses. Lytic and Lysogenic cycles. Production of vaccines.

### **Paper-3. MOLECULAR IMMUNOLOGY**

#### **UNIT-I**

Basic concepts of immunology ,Immunity : Innate and adaptive, Active & Passive immune response , recognition of self and non-self Antigens,immunogens, immunogenicity, antigenicity.Cells and Organs of the Immune System: Lymphoid cells, Haematopoiesis ,T cells, B cells, monocytes, phagocytes, mast cells and basophils, Dendritic cells, NK cells Primary and secondary lymphoid organs. Physiology of immune response, epitope analysis, synthetic peptides and immune response, immunity to virus, bacteria, fungi.

#### **UNIT-II**

Humoral Immunity : Immunoglobulins and their types,Antigen-antibody interactions, affinity, avidity, cross linking. molecular mechanism of generation of antibody diversity. Cell Mediated Immunity : T cell subsets and surface markers, T cell-dependent and -independent markers, structure and function of MHC, association of MHC with disease susceptibility, structure of T cell antigen receptor.

#### **UNIT-III**

Natural Immunity : stimuli, Inflammation, chemotaxis, arachidonic acid metabolite and cytokines, vascular modifications, healing and fibrosis. Natural Killer Cells : Functional definition, mechanism of lysis, recognition structures. Immune Memory : B-cell memory, significance, mutations and switches in memory cells, T-cell memory, lack of mutations and switches in T-cell memory, activation, superactivation, loss of memory. Complement system,Toll-like receptors.

#### **UNIT-IV**

Immune Tolerance : B-cell tolerance, reversible and irreversible tolerance, antigen induced tolerance, induction, T-cell tolerance, partial engagement of signal transducer, self-antigens, molecular consequence of tolerance. Disorders : Hypersensitivity reactions, immunosuppression, autoimmune disorders and its molecular mechanism, immunodeficiency disorders (AIDS), tumor immunology. Transplantation immunology.

#### **UNIT-V**

Immunobiotechnology : Hybridoma, vaccines, viral, bacterial peptides, genetically engineered production of lymphokines, second generation antibodies .Immunological techniques : immunodiffusion, immunoblot immuno fluorescence, immunoaffinity, ELISA, agglutination, immunoprecipitation, immunoelectrophoresis, biotinylation, avidin-streptavidin, cross-linking immunogens, immunomodulations.

## **Paper-4. ENZYME TECHNOLOGY**

### **UNIT-I**

Discovery, classifications and nomenclature of enzymes. Isolation & Purification of Enzymes. Techniques of Enzyme assay. Techniques used for molecular Profiling of enzymes., Isoenzymes. Multienzyme complexes and Multi functional enzymes.

### **UNIT-II**

Enzyme Kinetics- Michaelis Menten equation, Lineweaver Burk equation, Negative and Positive Co-operativity, Mechanism of enzyme action; Fischer's Lock & Key hypothesis, Khosland's induced fit hypothesis, Factors affecting the rate of enzyme catalyzed reactions, Significance of  $V_{max}$  and  $K_m$ . Units of enzyme activity, Specific activity of enzyme, Turn over number. Unisubstrate enzyme kinetics, Enzyme inhibition – type of inhibition; Competitive, non competitive and uncompetitive kinetics.

### **UNIT-III**

Functional proteins- structure and drug targets (enzymes and receptors). Enzyme modification, Enzyme engineering. Enzyme catalytic efficiency. Factors associated with catalytic efficiency Allosteric enzymes; Sigmoidal kinetics and their physiological significance; Symmetric and sequential modes for action of allosteric enzymes and their significance.

### **UNIT-IV**

Enzyme catalysis in solution - kinetics and Thermodynamic analysis, effects of organic solvents on enzyme Catalysis and structural consequences. Monomeric and Oligomeric enzymes; Serine proteases, Lactate dehydrogenase Pyruvate dehydrogenase, Tryptophan synthase, Pepsin (Acid Protease), Papain. Mechanism of action of chymotrypsin, Glyceraldehyde-3-Phosphate-dehydrogenase, Lysozyme, Carboxy peptidase, Ribonuclease, Aldolase.

### **UNIT-V**

Various techniques used for the immobilization of enzymes. Applications of immobilized enzyme in Biotechnology. Commercial exploitation of enzymes; food industry, Breweries, medicine, dairy, detergent, leather, paper industry.

### **Practical**

### **Seminar**

## **THIRD SEMESTER**

### **Paper-1. GENETIC ENGINEERING AND RECOMBINANT DNA TECHNOLOGY.**

#### **UNIT-I**

Introduction and emergence of r-DNA technology, tools and techniques in RDT, Restriction enzymes, linkers, polylinker, adapter. Basic principles of nucleic acid isolation and purification, plasmid DNA and phage DNA.

#### **UNIT-II**

Concept of Gene Cloning, cloning vectors; salient features and types, biology of bacteriophage lambda, Preparation of genomic and cDNA library, Selection and screening of recombinant clones: Direct and indirect methods. Probe preparation (radio labelling and non- radio labelling). Expression of cloned DNA, Expression vectors, Expression in heterologous system. Site directed mutagenesis. DNA microarrays for screening genes of interest from various organism. Gene

regulation analysis; Primer extension, S1 mapping, RNase protection assays, Phage display, Yeast two hybrid and three hybrid systems.

### **UNIT-III**

Principles and techniques of nucleic acid hybridization, Southern, Northern, Western, colony and plaque hybridization, in situ hybridization, Polymerase Chain Reaction, DNA fingerprinting, Artificial synthesis of gene.

### **UNIT-IV**

Molecular Mapping of Genome; Genetic and physical maps, chromosome walking, Restriction mapping, Chromosome micro dissection and micro cloning, Molecular markers in genome analysis: RFLP, RAPD, AFLP, SCAR, SSR, SNP, EST, QTL analysis, Application of molecular markers in forensic sciences, disease diagnosis, genetic counseling, Pedigree and varietal analysis, animal trafficking and poaching; Germplasm maintenance and Bio-diversity. Marker assisted selection in agriculture and live stock.

### **UNIT-V**

Somatic and germ line gene therapy, *ex vivo* & *in vivo* gene therapy. Genetic engineering and pharmaceutical products, Bio-plastic and other commercial products. Use of nucleic acid probes & antibodies in clinical diagnosis & tissue typing. Management and Commercialization aspects of Biotechnology & Genetic Engineering, Biosafety & Bioethics, Intellectual property rights: World organizations, Types (Patents, Copy rights, Trademarks, Trade secrets, Geographical indications, designs), Monitoring of GMOs.

## **Paper-2 BIOPROCESS TECHNOLOGY AND INDUSTRIAL BIOTECHNOLOGY.**

### **UNIT-I**

Introduction to bioprocess technology: Screening, preservation and improvement of industrially important micro organisms, Raw material and media formulation for fermentation process, Air and media sterilisation, Primary and secondary metabolites. Influence of environmental factors on growth and product formation.

### **UNIT-II**

Concepts of bioprocess, Bioreactor designing, Mixing and residence time distribution in bioreactor, Analysis of Batch, Fed –batch and continuous bio reactions, Pulse bioreactors, Fluidised bioreactors and Photo bioreactors, pneumatic and hydro dynamic fermenters, Solid substrate ,surface, submerged fermentation, Fermentation economics. Bioreactor design for animal cell culture and for waste treatment, Growth models.

### **UNIT-III**

Growth kinetics: Microbial growth cycle, measurement of growth, Control of process parameters: measurement of process parameters likes pH, temperature, Dissolved Oxygen, foam. Scale up and scale down process.

### **UNIT-IV**

Downstream processing: Cell separation, cell disintegration, Foam separation, Precipitation, Centrifugation, Drying, Crystallisation and product Purification, Effluent treatment. Bioprocess economics. Use of microorganisms in mineral beneficiation and oil recovery, Microbial leaching of minerals.



## **UNIT-V**

Industrially Important Microbial Metabolites : Process technology for the production of primary metabolites, e.g. baker's yeast, ethanol, acetone-butanol, citric acid, lactic acid, amino acids, polysaccharides, nucleosides and bioplastics; Production of secondary metabolites, penicillin, Cephalosporins, streptomycin, vitamins etc. Whole cell immobilization and their industrial application. Food technology: Elementary idea about canning, packing, sterilization and pasteurization of food products. Research methodology: Collection of literature, citation of literature, manuscript preparation, Indexing, abstracting and calculation impact factor, plagiarism.

## **Paper-3. ANIMAL CELL SCIENCE AND TECHNOLOGY**

### **UNIT-I**

Laboratory requirements and general techniques in animal cell culture. Sterilization procedures of glass ware and other accessories. Preparation of media, balanced salt solutions, membrane filtration, Role of carbon dioxide and serum in animal cell culture. Various type of cell culture media, Regulation of nutritional requirements, Cell counting and staining.

### **UNIT-II**

Mechanical and enzymatic desegregation of tissue and setting up of primary cultures. Candling of eggs, Animal cell growth characteristics, Growth kinetics, Cell culture in continuous, perfusion and hollow-fiber reactor; Mass transfer in mammalian cell culture. Preparation of chick fibroblast, Culture of lymphocytes for chromosomal studies. Organ and histotypic cultures. Three dimensional culture. Measurement of cell death, Cell transfection.

### **UNIT-III**

Measurement of viability, cytotoxicity and Biological characterization of the cultured cells, Maintenance of cell culture; Cryo- preservation & evaluation. Primary and established cell lines. Cell separation and synchronization, Cell transformation, Scaling up of animal cell culture. Culture and maintenance of various Stem cell and their applications.

### **UNIT-IV**

Transfection of animal cell lines and their immortalization, Construction of animal viral vectors for gene transfer into cell lines, Sperm mediated gene transfer Embryo transfer technology, Micro-manipulation, In-vitro fertilization, Production of transgenic animals and case studies.

### **UNIT-V**

Applications of animal cell culture. Somatic cell genetics. Molecular Pharming, Animal biotechnology for production of regulatory proteins, blood products, Cell culture based vaccines and hormones and other therapeutic proteins. Tissue engineering. Hybridoma technology.

## **Paper-4 a. PLANT BIOTECHNOLOGY**

### **UNIT-I**

Introduction to plant tissue culture; Tissue culture as a technique to produce novel plants and hybrids. Tissue culture media, Sterilisation techniques in plant tissue culture. Initiation and maintenance of callus, suspension cultures; Single cell clones. Organogenesis; Somatic embryogenesis, artificial seed /Synthetic seeds technology. Acclimatisation and Hardening. Shoot tip culture; Rapid clonal propagation.

## **UNIT-II**

Embryo culture and embryo rescue. Protoplast isolation, culture and fusion; Selection of hybrid cells and regeneration of hybrid plants; Symmetric and asymmetric hybrids, cybrids. Anther, pollen and ovary culture for production of haploid plants and homozygous lines. Cryopreservation; Slow growth and DNA banking for germplasm conservation. Somaclonal variation. In vitro mutation – Sexual incompatibility and male sterility.

## **UNIT-III**

Plant transformation technology – Basis of tumour formation; Hairy root; Features of Ti and Ri plasmids; Mechanisms of DNA transfer; Role of virulence genes; Use of Ti and Ri as vectors; Binary vectors; Use of 35S and other promoters; Genetic markers; Use of reporter genes; Reporter gene with introns; Use of scaffold attachment regions in transformation, Agroinfiltration. Methods of nuclear transformation; Viral vectors and their applications; Multiple gene transfers; Vector-less or direct DNA transfer; Particle bombardment, electroporation, microinjection; Transformation of monocots; Transgene stability and gene silencing.

## **UNIT-IV**

Application of plant transformation for productivity and performance – Herbicide resistance, insect resistance, Bt genes, Non Bt like protease inhibitors, alpha amylase inhibitor, virus resistance, coat protein mediated disease resistance, disease resistance, RIP, antifungal proteins, thionins, PR proteins, nematode resistance, abiotic stress. Terminator seed technology.

## **UNIT-V**

Application of Molecular markers in plant breeding, Chloroplast transformation – Advantages, Vectors, Success with tobacco and potato. Transgenic plants and their management (Advantages and disadvantages), case studies of transgenic plants. Metabolic engineering and industrial products – Plant secondary metabolites, Control mechanisms and manipulation of Phenylpropanoid pathway, Shikimate pathway; alkaloids. Green house and green home technology.

OR

## **Paper-4.b. Agricultural Biotechnology**

### **UNIT-I**

General application of biotechnology in Agriculture, Medicine, dairy and animal husbandry, Energy production and Forensics; Public perception of biotechnology. Early concepts of inheritance. Discussion on Mendel's paper; Sex determination, differentiation and sex-linkage, Sex-influenced and sex limited traits; Linkage, recombination and genetic mapping in eukaryotes, Somatic cell genetics. Structural and numerical changes in chromosomes; Mutations and mutagenic agents. Genetic code and protein biosynthesis; Extra chromosomal inheritance, Male sterility and incompatibility.

### **UNIT-II**

Inheritance of quantitative traits; Concepts in population genetics; Genetics and evolution; 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-splitting, embryo sexing.

### **UNIT-III**

Basic concepts in Animal cloning, 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.

### **UNIT-IV**

Introduction to 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, 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.

### **UNIT-V**

Principles of plant breeding; Breeding methods for self and cross pollinated crops; Heterosis Breeding; Limitations of conventional breeding; Aspects of molecular breeding. Development of sequence based molecular markers - SSRs and SNPs; Advanced methods of genotyping; Mapping genes for qualitative and quantitative traits. 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 and marker assisted selection in plant breeding.

### **Practical**

### **Summer training (Internal)**

## **FOURTH SEMESTER**

### **Paper-1. ENVIRONMENTAL BIOTECHNOLOGY**

#### **UNIT-I**

Environment: Basic concepts and issues. Concept and dynamics of Ecosystem, System analysis, Chemical and Bio-chemical Transformation, Geohypothesis, Features of Natural Balance, Contamination of Environmental segments by Man's action. Environmental Biotechnology and its Current Status .Methodology of environmental management - problem solving approach and its limitations.

#### **UNIT-II**

Environmental Pollution: Types of pollution & Types of wastes, Methods for the measurement of pollutants& waste. Air pollution and its control through Biotechnology. Water Pollution: Water as a scarce natural resource, Need for water management, Measurement of water pollution, sources of water pollution, Waste water collection and its treatment by physical and chemical processes. Waste water treatment by aquatic macrophytes.

### **UNIT-III**

Microbiology of Waste Water Treatment, Aerobic Process: Activated sludge, Oxidation ditches, oxidation ponds., trickling filter, towers, rotating discs, rotating drums. Anaerobic Processes: Anaerobic digestion, anaerobic filters, anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar, chemical and antibiotic industries.

### **UNIT-IV**

Sources of industrial and mining heavy Metal Pollution, Microbial Systems for Heavy Metal Accumulation, Biosorption, Bioleaching., bioaugmentation, Packaged Microorganisms, Plasmid Borne Metabolic Activities, Use of Genetically Engineered Organisms in pollution abatement, role of biosensors in Environmental monitoring.

### **UNIT-V**

Bioremediation: Types of bioremediation, use Histories, Constraints and Priorities of Bioremediation, Applications of Bioremediation, Xenobiotics, Oil Spills .Deodorization Process, Solid Waste Management, Vermitechnology, Bioenergy and its applications, Waste Water Treatment Using Aquatic Plants, Root Zone Treatment. Treatment and phytoremediation of industrial effluents and solid wastes from industries. Aiming for Biodegradable and Eco-friendly Products.

## **Paper-2. MEDICAL BIOTECHNOLOGY**

### **UNIT-I**

Introduction to Medical Biotechnology, Molecular process of hearing , smell ,taste, touch, pain, analgesics, Muscle movement. Molecular Physiology of heart, blood clotting ,vascular diseases and their treatment in the field of medical Biotechnology, Current trends in Molecular Endocrinology. Free radical biology.

### **UNIT-II**

Molecular biology of Development, Oogenesis and spermatogenesis, Egg activation, Fertilization With reference to acrosomal reaction & signal transduction, monospermy & species specificity. Genetic basis of development. Molecular mechanism of Erythropoiesis, ageing, Inheritance of quantitative traits and influence of environment on gene expression.

### **UNIT-III**

Hardy Weinberg's Principle & its application for Autosomal genes. Functional Organisation of Centromeres & Telomeres, Human Pedigree analysis, Congenital disorders; Haemoglobinopathies ( Sickle cell Anemia, Thalassaemia,G6PD deficiency) molecular mechanism of Alzheimer, Parkinson's disease, AIDS, Bird flu, Cystic fibrosis, Breast Cancer.

### **UNIT-IV**

Status of post human genome era, Stem cell Biology, Terratomas, Artificial blood, Karyology & Karyotyping, Knockout mice (Single, Double knockout)Concepts of Vaccine development . Selection of target antigen, production of recombinant antigens & their application, Virus cultivation & Purification.

### **UNIT-V**

Biotech based drugs & therapeutics. Nanotechnology and its applications in molecular medicine. Social and Ethical aspect of Medical Biotechnology (Genetic discrimination, Human cloning, Feticides, Sex determination).

**OR**

**Paper-2. AQUATIC BIOTECHNOLOGY**

**UNIT-I**

Introduction, present status of the knowledge, scope and importance of aquatic biotechnology, physico-chemical aspects of aquatic biology. Planktons & their role in aquatic biotechnology, nutritional biology of fresh water fishes.

**UNIT-II**

Marine Ecosystem & Principles of Oceanography. Marine Pollution & Bio-deterioration. Marine Biotechnology and its potential. Drugs and Bioactive compounds from the sea weeds, screening of oil degrading micro-organisms; Risk assessment of genetically modified organisms.

**UNIT-III**

Isolation & characterization of biotechnologically important enzymes from hot water springs and aquatic ecosystems, Biological productivity of aquatic ecosystems, Extremophilic, thermophilic, hypersaline organisms and their role in biotechnology. Sea weed resources, cultivation and propagation, therapeutic and agricultural applications of blue green algae, bio-absorption by sea weeds.

**UNIT-IV**

Modern concepts in fish biotechnology, Fish genetics and development of transgenic fishes. Cryo-preservation in fishes, genetic requirements for transgenic fish production. Applications of transgenic fishes and biotechnology. Cytogenetics of fishes.

**UNIT-V**

Chromosomal manipulation in fishes, fish hormones, induced breeding, DNA fingerprinting in aquatic biotechnology, Genotoxicity assays for environmental impact assessment, Probiotics in aqua- culture, Microbial diseases of fishes and their control.

**OR**

**Paper-2. Pharmaceutical Biotechnology**

**UNIT-I**

Biotransformation of drugs; Enzymes responsible for biotransformation; Microsomal and non-microsomal mechanisms. Factors influencing enzyme induction and inhibition; Extraction of drugs; Biliary and fecal excretion; Factors effecting drug metabolism; Drug metabolism in fetus and new borns. Models to study drug metabolism; Dose effect relationships; Adverse drug reactions and drug interactions; Toxic reactions; Allergic reactions; Idiosyncrasy; Acute poisoning and its treatment.

**UNIT-II**

Pharmacological screening models for therapeutic areas such as hypertension, cerebral ischaemia, pain, epilepsy, depression, Parkinson's disease, Alzheimer's disease, diabetic, leishmania etc. Correlation between in-vitro and in-vivo screens; Special emphasis on cell-based assay, biochemical assay, radio ligand binding assay; High throughput screening.

**UNIT-III**

Protein Modeling: Introduction; Force field methods; Energy, Buried and exposed residues; Side chains and neighbors; Fixed regions; Hydrogen bonds; Mapping properties onto surfaces; Assigning secondary structures; Sequence alignment- methods, evaluation, scoring; Protein completion: backbone construction and side chain addition; Small peptide methodology.

## UNIT-IV

Peptidomimetics: Introduction, classification; Con-formationally restricted peptides, design, pseudopeptides, peptidomimetics and transition state analogs; Biologically active template; Amino acid replacements; Peptidomimetics and rational drug design; CADD techniques in peptidomimetics; Development of non peptide peptidomimetics. Protein Structure Prediction: Protein folding and model generation; Secondary structure prediction; Analyzing secondary structures; Protein loop searching; Loop generating methods; Loop analysis; Homology modeling: potential applications, description, methodology, homologous sequence identification; Align structures, align model sequence; Construction of variable and conserved regions; Threading techniques.

## UNIT-V

Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements. Production of Biotech compounds: cultivation , downstream processing, issues to be considered in production and purification of proteins. Formulation of Biotech products, pharmacokinetics and pharmacodynamics of protein drugs, Dispensing of biotechnology products.

## Practical

### Project (Thesis + Presentation + Viva)

## SEMESTER WISE PRACTICALS

### Semester-1

- Validation of Beer Lambert's law by UV-Visible spectroscopy.
- Titration curves of amino acids.
- Paper chromatography
- Colorimetric determination of pK.
- Qualitative Analysis of amino acids, sugars and lipids
- Analysis of oils-iodine number
- Estimation of protein content by Lowry's & Biuret method
- Estimation of DNA content in the given sample by diphenylamine method.
- Estimation of RNA content by the Orcinol method.
- Estimation of reducing sugars by DNS method.
- Isolation and estimation of casein from milk.
- Preparation of buffers
- Chlorophyll estimation
- Microscopy
- Microtomy.
- Electron microscopy : Demonstration and good photographs for interpretation
- Mitosis & Meiosis.
- Separation techniques (Demonstration of HPLC)

- Preparation of Polytene chromosome
- Bioinformatics –tools on line.

## **Semester -2**

- 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.
- Isolation of pure cultures from soil and water.
- Study of growth curve
- Microscopic examination of bacteria by Gram stain, Acid fast stain
- Assay of antibiotics and demonstration of antibiotic resistance.
- Purity determination and quantitation of DNA
- Isolation of genomic DNA.
- Electrophoresis of Proteins
- Electrophoresis of DNA - linear, circular and super coiled
- Southern blotting.
- Western-blotting
- Northern blotting.
- Determination of  $T_m$  of nucleic acid.
- Immuno precipitation.
- Agglutination
- ELISA
- Blood film preparation and identification of various blood corpuscles.
- Haemocytometry
- Lymphoid organs and their microscopic observation
- Collection & storage of Serum.
- Double diffusion and Immuno-electrophoresis.
- Immunodiagnosics (demonstration using commercial kits).
- Estimation of hemoglobin content in blood.
- Extraction of enzyme from plant/animal sources.
- Enzyme concentration by salt fractionation.
- Determination of optimum pH, temperature,  $K_m$  of the enzyme.

## **SEMESTER-3**

- Plasmid isolation by alkaline lysis and boiling method.
- Transformation of plasmid using competent bacterial cells.
- Restriction mapping.
- Amplification of gene by PCR.
- Study of induction effect of B-galactosidase enzyme in *E.coli* cells.
- Demonstration of DNA sequencing.
- Gene Cloning.
- Preparation of animal tissue culture medium and membrane filtration.
- Preparation of single cell suspension from spleen and thymus.
- Cell counting and cell viability.
- Chick fibroblast culture.
- Trypsinization of monolayer and sub culturing.

- Transfection of cultured monolayer.
- Cryopreservation and thawing.
- Measurement of doubling time.
- Role of serum in cell culture.
- Preparation of metaphase chromosomes from cultured cells.
- Sterilization of plant materials
- Tools and glass wares used for plant tissue culture and their sterilization.
- Preparation of Plant tissue culture media
- Initiation of callus.
- Organogenesis
- Isolation and culture of plant protoplasts
- Embryo culture
- Anther/Microspore culture
- Axillary bud proliferation
- Introduction to Green House.
- Agroinfiltration
- Cell fusion with PEG.

## **SEMESTER-4**

- Detection of coliforms for determination of the purity of potable water.
- Determination of total dissolved solids of water.
- Determination of dissolved oxygen concentration of water sample.
- Determination of biological oxygen demand (BOD) of a sewage sample.
- Determination of chemical oxygen demand (COD) of sewage sample.
- Determine the efficiency of removal of air pollutants using fibrous air filter.
- Isolation of microbes for xenobiotic studies
- Test for the degradation of aromatic hydrocarbons by bacteria.
- Isolation of degradative plasmids in microbes growing in polluted environment.
- Estimation of heavy metals in water/soil by Atomic absorption spectrophotometer.
- Estimation of nitrate in drinking water.
- Isolation of industrially important microorganisms for microbial processes.
- Determination of thermal death point (TDP) and thermal death time (TDT) of microorganism to design a sterilizer.
- Comparative studies of Ethanol production using different substrates.
- Microbial production of Citric acid using *Aspergillus niger*.
- Microbial production of antibiotics.
- Production and estimation of Protease/ lipase/ amylase.
- Use of alginate for cell immobilization.



## RECOMMENDED BOOKS FOR THE COURSE

- Molecular Biology of the Cell, Alberts. B Garland publishing, Inc., New York et al.
- Molecular Cell Biology, Lodish Scientific American Books, Inc., USA et al.
- Reproduction in Eukaryotic cells, DM Prescott, Academic press.
- Developmental Biology, SF Gilbert, Sinauer Associates Inc.
- Cell in Development and inheritance, EB Wilson, MacMilan, New York.
- The Coiled Spring, Ethan Bier, Cold Spring Harbor Press.
- Fertilization, FT Longo, Chapman and Hall.
- Molecular Biology of Steroid and Nuclear Hormone Receptors, LP Freedman,
- Biochemical Engineering, Aiba, S., Humphrey, A.E. and Millis, N.F. Univ. of Tokyo Press, Tokyo.
- Biochemical Reactors, Atkinson, B., Pion Ltd. London.
- Physical Chemistry of Macromolecules, Tanford, C., John Wiley and Sons.
- Introduction to Biophysical Chemistry, RB Martin, McGraw Hill, New York.
- General Microbiology, Stainer, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, P.R. The Macmillan Press Ltd.
- Microbiology, Pelczar, M.J. Jr., Chan, E.C.S. and Kreig, N.R., Tata McGraw Hill.
- Microbial Genetics, Maloy, S.R., Cronan, J.E. Jr. and Freifelder, D. Jones, Bartlett Publishers.
- Microbiology a laboratory Manual, Cappuccino, J.G. and Sherman, N. Addison Wesley.
- Microbiological Applications (A Laboratory Manual in General Microbiology) Benson, H.J. WCB: Wm C. Brown Publishers.
- Methods for general and Molecular Bacteriology by Gerhardt et al. (1994) ASM Press.
- Microbiology by Prescott, Harley and Klein (1996) William C. Brown Press.
- Brock's Biology of microorganisms. (1997). Madigan, M., Martinko & Parker, J.
- Microbiology: Fundamentals and Applications. (1989). Atlas, R.M.
- Introductory Microbiology. (1986). Merrill, C.H.
- General Microbiology. (1987). Stanier, R.Y., Ingraham, Wheelis and Painter
- Microbiology. (1980). Davis, D. et al.
- Marine and Estuarine Microbiology Laboratory Manual. (1975). Colwell, R. et al.
- Microbiology Methods. (1975). Collins, C.H. and Lyne, P.M.
- Source book of Experiment for the teaching of Microbiology. (1982). Primrose, S.B. and Wardlaw, A.C.
- Laboratory Methods in Microbiology. (1973). Harrigan, W.F. & McCance, M.E.
- Biophysics. (1983). Volkenstein, M.V.
- Introduction to Biophysical Chemistry. Martin
- A Biologist guide to principles and techniques of practical biochemistry. (1975).
- Bryan, W. & Keith, W.
- Biophysical chemistry Part I & III by Cantor and Schimmel (1980) WH Freeman & Company.
- Nucleic acid structure by S. Neidle (ed) (1987) VCH Publishing, Weinheim.
- Principles of Instrumental analysis by D.S. Skoog (1985) H.L. Saunders.
- Laboratory Manual of Biochemistry by J. Jayaraman (1980) Wiley Eastern.

- Williamd, B.L. and Wilson, K, Principles and techniques of practical biochemistry (1995) Edward Arnold.
- Physical Biochemistry: David Freifelder Instrumental methods of analysis: Willard, Merrit, Dean and Settle. Spectroscopy: D.R.Browning
- Instrumental methods of analysis: D.A.Skoog
- Molecular Cloning: A Laboratory Manual, J. Sambrook, E.F. Fritsch and T Maniatis, Cold Spring Harbor laboratory Press, New York, 2000
- Introduction to Practical Molecular Biology, P.D. Dabre, John Wiley & Sons Ltd., New York, 1988
- Molecular Biology LabFax, T.A. Brown (Ed.), Bios Scientific Publishers Ltd., Oxford, 1991
- Molecular Biology of the Gene (4th Edition), J.D. Watson, N.H. Hopkins, J.W. Roberts, and J. D. Watson. Garland publishing, Inc., New York, 1994
- Gene VI (6th Edition) Benjamin Lewin, Oxford University Press, U.K., 1998 VCH Publishers, Inc., New York, 1995
- Genomes, T.S. Brown
- The Molecular Biology of the Cell by Alberts et al. (1991)
- The Molecular Biology of the Gene by J. D. Watson et al. (1987) Benjamin Cummings.
- Gene V by B. Lewin (1994) Oxford University Press, Oxford.
- Cell Biology : DeRobertis and DeRobertis.
- Cell and Molecular biology: G.Karp
- Molecular Biology of the cell: J.D. Watson et al
- Monoclonal antibodies: Principles and practice. Golding, J.W.
- Immunogenetics: Zaleski, D. & Cunningham, N.
- Monoclonal antibodies: Principles and practice (1983). Golding, J.W.
- Harrison's Principles of internal medicine vol.I & II (1987). Braunwald, E., Isselbaches, K.J., Petersdorf, R.G., Wilson, J.D., Martin, J.B. & Fauci, A.S.
- Basic and clinical immunology (1984). Stites, D.P., Stobo, J.D., Fudenberg, H.H. & Wells, J.V.
- Immunology. (2000) Kuby,J.
- Essential Immunology, (1997), Roitt, L.M.
- Immunology. (1996). Reeves and Todd
- Immunology for students of Medicine, Humfrey, J.H. & White, R.G.
- Basic and Clinical Immunology, Stites, D.P., Stobo, J.D. & Wells, J.V.
- The Experimental Foundations of Modern Immunology, (1983). Clark, W.R.
- Fundamentals of Immunology, (1996). Boyd, W.C.
- Foundations of Immunology, Baret.
- Handbook of Experimental Immunology. Vol. I & II. (1986) by Weir, D.M.
- Manual of Clinical Laboratory Immunology (1997), Rose, N.R.
- Introductory Immunology : Huw Davies.
- Immunology-A short Course, 4th Edition, - Eli Benjamini, Richard Coico, Geoffrey Sunshine. (Wiley-Liss)
- Fundamentals of Immunology, William Paul.
- Enzymes. (1979). Dixon M. & Webb E.C.
- Fundamentals of Biochemistry. (1986). Mahler, H.R. and Cordes, E.
- Genes VII. (2000). Lewin, B.
- Biological Chemistry. (1986). Mahler, H.R. and Cordes E.

- Methods in enzymology. Vol XXII. Colowick, S.P. & Kaplan, N.O.
- Fundamentals of Enzymology : Nicholes C. Price and Lewis Stevens, Oxford Univ. Press.
- Enzyme Structure and mechanism: Alan Fersht, Reading, USA.
- Understanding Enzymes : Trevor Palmer
- The chemical kinetics of enzyme action : K. J. Laider and P. S. Bunting, Oxford University Press, London
- Culture of Animal Cells, (3rd Edition), Freshney, Wiley-Liss.
- Animal Cell Culture - Practical Approach, Ed. John R.W. Masters, OXFORD,
- Cell Growth and Division: A Practical Approach. Ed. R. Basega, IRL Press.
- Animal Cell Culture Techniques. Ed. Martin Clynes, Springer.
- Methods in Molecular Biology, Vol.7, Humana Press.
- Recombinant DNA. J.D. Watson, M. Gilamn, J. Witkowski and M. Zoller.
- Scientific American Books, NY.
- Molecular Biotechnology, II edition, Bernard R Glick and Jack J. Pasternack. Asm Press.
- Animal cell culture. (1981). Pollack, R. & Feiffer, S.P.
- Animal cell biotechnology. (1989). Spier, R.E. & Griffith, J.B. (Ed).
- Plant cell & tissue culture. (1994). Vasil, I.K. & Thorpe, T.A.
- Plant tissue culture: Applications and limits. (1990). Bhojwani, S.S.
- Plant tissue culture: Theory and Practice. (1983). Bhojwani, S.S. & Razdan, M.K.
- Plant propagation by tissue culture. (1984) George, E.F. & Sherrington, P.D.
- A manual of laboratory experiences in Cell Biology. (1992). Gasque, C.E.
- Basega, R. (ed): Cell Growth and Division : A Practical Approach. IRL Press.
- Butler, M and Dawson, M. (eds.): Cell Culture Lab Fax, Eds., Bios Scientific Publications Ltd., Oxford.
- Clynes, M. (ed): Animal Cell Culture Techniques. Springer.
- Mather, J.P and Barnes, D. (eds). : Methods in Cell Biology, Vol. 57, Animal Cell Culture Methods. Academic Press.
- Plant biotechnology – J Hammond, et. al., Springer Verlag.
- Plant cell and tissue culture for production of food ingredients – T J Fu, G Singh, et. al. Biotechnology in crop improvement – H S Chawla.
- Practical application of plant molecular biology – R J Henry, Chapman & Hall.
- Elements of biotechnology – P K Gupta.
- An introduction to plant tissue culture – M K Razdan.
- Plant propagation by tissue culture: The technology (Vols. 1 & 2) – Edwin George.
- Handbook of plant cell culture (Vols. 1 to 4) – Evans et. al., Macmillan.
- Plant tissue and cell culture – H E Street, Blackwell Scientific.
- Cell culture and somatic cell genetics of plants (Vols. 1 to 3) – A K Vasil, A. Press.
- Plant cell culture technology – M M Yeoman. Plant tissue culture and its biotechnological applications – W Bary, et. al., Springer Verlag.
- Principles of plant biotechnology : An introduction to genetic engineering in plants – S H Mantell, et. al.
- Advances in biochemical engineering / Biotechnology – Anderson, al.
- Applied and fundamental aspects of plant cell tissue and organ culture edited by Reinert & Bajaj Y P S, SpringerVerlag.
- Plant cell and tissue culture – S Narayanswamy, Tata Mc Graw Hill Co.
- Plant Molecular Biology by Grierson and S.N. Covey (1988) Blackie.

- Plant Biochemistry and Molecular Biology by P.J.Lea and R.C.Leegood (1993) John Wiley & Sons.
- Plants, Genes and Agriculture by M.J. Chrispeels and D.F.Sadava (1994) Jones and Bartlett.
- Molecular Genetics of Photosynthesis by B.Anderson, H.Salter and J.Barber (1996), IRL Press, Oxford.
- Plant Virology (3rd Edition) by R.E.E.Mathews (1991) Academic Press.
- Principles of gene manipulation by RN.Old & SB.Primrose (1994) Blackwell Scientific Publications.
- DNA cloning I & II by DM. Glover & BD. Hames (1995) IRL Press.
- Concepts in Biotechnology – Editors D.Balasubramanian et al. University Press, (1996).
- Biotechnology, Annual Review Edited by M.R. EL-Gewelly Elsevier Publications, Amsterdam.
- Gene therapy-Edited by N.R.Lemoine and D.N.cooper BIOS Scientific Publishers, Oxford.
- Diagnostic Molecular Microbiology. Principles and Application Edited by David H.Persing et al. American Society for Microbiology, Washington D.C.
- Methods in Molecular Biology vol.62 Edited by R.S.Tuan, Humana Press, Totowa, New Jersey.
- Biotechnology. (1998). Singh, B.D.
- Genetic engineering: principles & practice (1996). Mitra, S.
- Principles of gene manipulations (1996) Old,R.W. & Primrose,S.B.
- The basic principles of gene cloning (1996). Brown, T.A.
- An introduction to Genetic engineering.(1994). Nicholl,D.S.T.
- Recombinant DNA. (1992). Watson et al.
- Genetic engineering fundamentals: An introduction to principles & applications. (1989). Kammermeyer,K. & Virginica,C.
- From Genes to Clones: Introduction to Gene Technology. (1987). Winnacker, E.L.
- Genetic engineering Vol I-VI Setlow and Halander.
- Genetic engineering Vol I-IV (1981). Williamson, R.(Editor).
- Molecular cloning (1989) Maniatis,T. *et al*
- Recombinant DNA methodology. (1985). Dillon, R.G., Nasim, A. & Nestmann. E.R.
- Biotechnology and pharmacy (1993). Pezzato, J.M., Johnson, M.E. & Manasse, H.R. (Ed).
- Biotechnology current progress Vol.-I. (1990). Cheremisinoff, P.N. & Fenante, L.M. (Ed)
- Molecular Biotechnology: Principles and applications of recombinant DNA. (1994) Glick, B.R. & Pasternac, J.J.
- Intellectual property rights in biotechnology. A status report (1993). Singh, K.
- Biotechnology: The science and business (1991). Moses, V. & Cape, R.E.
- Biotechnology and Genetic Engineering reviews (1988). Russel, G.E.
- Biotechnology for Aerospace applications (1989). Obringer, J.W. & Tilling, H.S.(Ed)
- DNA Cloning: A Practical Approach, .M. Glover and B.D. Hames, IRL Press, Oxford, 1995.
- Molecular and Cellular Methods in Biology and Medicine, P.B. Kaufman, W. Wu. D. Kim and L.J; Cseke, CRC Press, Florida, 1995.
- Methods in Enzymology Vol. 152, Guide to Molecular Cloning Techniques, S.L. Berger and A.R. Kimmel, Academic Press, Inc. San Diego, 1998.
- Methods in Enzymology Vol 185, Gene Expression Technology, D.V. Goeddel, Academic Press, Inc., San Diego, 1990.

- DNA Science. A First Course in Recombinant Technology, D.A. Mickless and G.A. Froyer. Cold Spring Harbor Laboratory Press, New York, 1990.
- Molecular Biotechnology (2nd Edn.), S.B. Primrose. Blackwell Scientific Publishers, Oxford, 1994.
- Milestones in Biotechnology. Classic papers on Genetic Engineering, J.A. Davies and W.S. Reznikoff, Butterworth-Heinemann, Boston, 1992.
- Genetic Engineering. An Introduction to gene analysis and exploitation in eukaryotes, S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford, 1998.
- Wastewater Engineering - Treatment, Disposal and Reuse, Metcalf and Eddy, Inc., Tata McGraw Hill, New Delhi.
- Comprehensive Biotechnology. Vol. 4, M. Moo-Young (Ed-in-chief), Pergamon Press, Oxford.
- Environmental Chemistry. A.K. De, Wiley Eastern Ltd., New Delhi.
- Introduction to Biodeterioration. D. Allsopp and K.J. Seal. ELBS/Edward Arnold.
- Waste water Engineering Treatment and Disposal and Reuse" by Metcalf & Eddy.
- "Water Pollution Management Hand Book" by Lepathak.
- "Waste Water Management" by Arceivala.
- "Environmental Biotechnology" by C. F. Forster and D. A. J. Wase.
- "New Processes of Waste water treatment and recovery" by G. Mattock (ED) Ellis Horwood.
- "Biochemical Engineering fundamentals" 2nd ed. by J E Bailey and D F Ollis , McGraw - Hill (1986). Chapters 13 & 14.
- "Environmental Biotechnology" by Jogdand.
- Encyclopedia of bioprocess technology. Vol 1-5. (1999). Flickinger, M.C. & Drew, S.W.(Ed).
- Fermentation technology. (1994). Cassida.
- Bioprocess engineering: Down stream processing & recovery of bioproducts, safety in biotechnology and regulations. (1990). Behrens, D. & Kramer, P.(Ed).
- Fundamentals of biotechnology. (1987). Prave, P., Fanst, V., Sitting, W. & Sukatesh, D.A. (Ed.)
- Comprehensive biotechnology. Vol 2-4. (1985). &Young, M. (Ed)
- Chemical engineering. (1984). Coulson, J.M. & Richardson, J.F.
- Principles of fermentation technology. (1984). Stanbury, F. & Whitaker, A.
- Immobilized enzymes: An introduction & application in biotechnology. (1980). Trevan, M.D.
- Topics in enzyme & fermentation technology. (1984). Wiseman, A. (Ed).
- Principles of Fermentation Technology : Whitekar & Stanbury
- Biological chemistry by H.R. Mahler and E. Cordes (1986)
- Textbook of Fish Genetics and Biotechnology/edited by P.V.G.K. Reddy, S. Ayyappan, D.M. Thampy and GopalKrishna. New Delhi, Indian Council of Agricultural Research.
- Fish Biotechnology/M. M. Ranga and Q. J. Shammi. Jodhpur, Agrobios, 2002, 259 p., \$33. ISBN 81-7754-093-9.
- An introduction to fishes, Dr.S.S .Khanna, Central Book Depot Allahabad,UP
- Fish Genetics & Biotechnology Dr.W.S.Lakra. ICAR Publication.

- Biotechnological Methods of Pollution control Dr.Abbasi, University Press, New Delhi.
- Bioinformatics Basics: Applications in Biological Science and Medicine by Hooman H. Rashidi, J. Howard Parish.
- Instant notes Bioinformatics by P.M.Lydyard, A. Whelan and M.W . Fanger
- Fundamentals of Bioinformatics, by Dan E.Krane, Michael L. Raymaer
- Basics Bioinformatics By S.Ignacimuthu
- Bioinformatics sequence and genome analysis David W. Mount.
- Bioinformatics managing scientific data by Zoelacroix.
- Bioinformatics a practical guide to the analysis of genes and proteins by Baxevanis and Quелlette.
- Essential genomics and bioinformatics by Senson.
- Introduction to Bioinformatics T.K Attawood.
- Bioinformatics by Taylor
- Bioinformatics and human Genome by Mishra
- Bioinformatics: Concepts, Skills & applications.
- Bioinformatics: Machine Learning approach 2<sup>nd</sup> Edition by Baldi.
- Recent Advances in Bioinformatics by Khan.
- Bioethics for scientists by Bryant.
- Patent strategy by Knight.
- Bioethics by Arya.
- What every one should know about patents by Subbran.
- Intellectual Property in agricultural Biotechnology by F.H Erbisch & C.Velazquez.
- Chittaranjan K. 2006-07. Genome Mapping and Molecular Breeding in Plants. Vols. I-VII.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.
- 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.
- 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.

- Pierik RLM. 1997. *In vitro Culture of Higher Plants*. Kluwer.
- Singh BD. 2007. *Biotechnology: Expanding Horiozon*. Kalyani.
- Klug WS & Cummings MR. 2003 *Concepts of Genetics*. Peterson Education.
- Lewin B. 2008. *Genes IX*. Jones & Bartlett Publ.
- Russell PJ. 1998. *Genetics*. The Benzamin/Cummings Publ. Co.
- Strickberger MW.1990. *Genetics*. Collier MacMillan.
- Tamarin RH. 1999. *Principles of Genetics*. Wm. C. Brown Publs.
- Uppal S, Yadav R, Subhadra & Saharan RP. 2005. *Practical Manual on Basic and Applied Genetics*. Dept. of Genetics, CCS HAU Hisar.
- Goodman & Gilman, Laurence L Brunton, *The Pharmacological Basis of Therapeutics*, 11th Edition, McGraw Hill, New York, 2005.
- Thomas F. Woolf, *Handbook of Drug Metabolism*, Marcel Dekker, New York, 1999.
- Bertram G. Katzung, *Basic and Clinical Pharmacology*, 8th Edition, Lange Meical, New York, 2000.
- David W. Mount, *Bioinformatics: Sequence and Genome Analysis 2nd Edition*, CSHL Press, 2004.
- A. Baxevanis and F. B. F. Ouellette, *Bioinformatics: a practical guide to the analysis of genes and proteins*, 2<sup>nd</sup> Edition, John Wiley, 2001.
- Jonathan Pevsner, *Bioinformatics and Functional Genomics*, 1st Edition, Wiley-Liss, 2003.
- P. E. Bourne and H. Weissig, *Structural Bioinformatics*, 2nd Edition, Wiley, 2008.
- C. Branden and J. Tooze, *Introduction to Protein Structure*, 2nd Revised Edition Garland Publishing, 1998.
- A.K.Panigrahi & Alaka Sahu (2012). *A text book of Environmental studies*. Giribala Publications. Berhampur.
- M.C.Dash & P.C.Mishra. *Man and Environment*.
- R.L.Smith. *Ecology and field biology*.
- O.P.Odum. *Fundamentals of Ecology*.