1. **Genetic Engineering** 1hr
2. **Genetic cloning techniques** 4 hrs
   Introduction, Techniques: Restriction enzymes and restriction digestion, other enzymes used for DNA manipulation: synthesis, joining and modification, gel-electrophoresis: Principle, types, process and uses
3. **PCR Techniques** 3 hrs
   DNA polymerase and RNA-polymerase used in PCR, Role of Mg++ and NTPs, PCR techniques and uses, Use of PCR in gene assembly: multiplex PCR, Overlap extension PCR. Real-time quantitative PCR. PCR in molecular diagnostics, application of RT-PCR in gene expression
4. **DNA cloning and expression** 10 hrs
   **Cloning vectors**: plasmid, polylinker, lambda vector (phagemids), cosmid, Artificial chromosomes, marker and reporter gene, genetic transformation of E. coli and selection, DNA recombination without ligase: topoisomerase, cre-lox recombination, Gate way method,
   **DNA library**: genomic library, cDNA library, expression library, subtraction library Cloning strategies, cloning in bacteria other than *E. coli*, cloning in yeast and other fungi, gene manipulation of animals and plants, Analysis of transcriptome, expression analysis of protein
   **Expression systems**: Recombinant DNA technology, Synthesis of protein through expression vector, fusion protein, prokaryotic: expression system in E.coli, Bacillus expression, eukaryotic : Pichia expression system; expression in insects system (Baculovirus expression system); Protein expression in mammalian cells
5. **Identification, isolation and sequencing of cloned DNA** 7 hrs
   Direct selection of gene, Oligonucleotide probes (radioactive and nonradioactive) Nucleic acid hybridization: southern blotting, northern blotting, Library screening by membrane hybridization, Western Blotting and immunoscreening for expression library
   **Methods of DNA sequencing**: Maxam and Gilbert, Sanger and Coulson, improvement in the methods, Pyro sequencing, next generation sequencing, Microarray and sequencing
6. **Method of transformation** 3 hrs
   **Direct transformation**: electroporation, microinjection, micro projectile bombardment, direct uptake of DNA fragment
   **Indirect method**: through Ti-plasmid, conjugation, transduction
7. **Functional genomics** 5 hrs
   Mutation and induced mutation, Use of PCR in site directed mutagenesis and protein engineering, knockout mutation, role of transposons in mutation, isolation and analysis of mutants, genetic mapping of mutation, cloning of mutated gene, proteomics and genomics.
8. **Microarray techniques and uses** 1 hr

Practicals

1. **DNA recombination and transformation**
   - Plasmid extraction and Construction of chimeric plasmid
   - Production of competent *E. coli*, *Pichia*
   - Transformation of *E. coli* cells and *Pichia* and selection of transformant
   - Selection of transformant by blue white screening
   - Electroporation
2. **PCR techniques**
   - Amplification of particular DNA sequence by normal PCR
   - Cloning of PCR product in vector
   - Preparation of cDNA by Reverse transcriptase PCR (RT-PCR), Other PCR techniques
3. **Hybridization techniques**
   - Labeling of nucleic acid and preparation of nucleic acid probe
   - Southern blotting, Northern blotting, Western blotting
4. **Production of fusion protein using expression vector (pET) and purification**
5. **Visualization of GFP**
6. **DNA sequencing technique**

Immunology and Immunotechnology

1. **Introduction on Immunology** 2 Hrs
   Brief history of Immunology, Epithelial barrier (First line defense), Innate (non specific second line) and adaptive (specific, third line defense) immunity. Concept of humoral and cell mediated immune response

2. **Cells, tissues and organs of immune systems** 3 Hrs
   Lymphocytes, NK cells, mast cells. Antigen presenting cells: dendritic cells, Macrophages, B cells. Functional anatomy of the immune system: Bone marrow, thymus, lymph node, spleen. Mucosal Immunity:, MALT (Mucosal-Associated Lymphoid Tissues), GALT (Gut Associated LT), BALT (Bronchus Associated LT), Cutaneous Immunity: CALT (Cutaneous-Associated Lymphoid Tissue).

3. **Antigens** 3 hrs
   Immunogenicity and antigenicity. Factors influencing immunogenicity. Types and characteristics of antigens: immunogens, Epitopes, haptens, Mitogens, Superantigens.

4. **Humoral Immunity** 6 Hrs
   Activation and differentiation of B cell. Germinal centre activity. Structure, classification and function of antibodies. Isotypes, allotypes, ideotypes. Synthesis assembly and expression of immunoglobulin molecules. B cell receptor. Antibody response. Immunoglobulin Genes and Generation of antibody diversities.

5. **Cell Mediated Immunity** 8 Hrs
   T cell activation, differentiation and Maturation. Understanding self and non self discrimination. T cell sub types (cytotoxic, helper, regulatory). T cell receptors. Role and structure of MHC molecules. Antigen processing and presentation by MHC I and II molecules. Interaction of T cell receptor with MHC I and II peptides and antigens.

6. **Effecter Mechanism of Immune Response** 9 Hrs
   Cytokines and chemokines: structure, type, function and their receptor. Therapeutic use of cytokines and their receptor. Complement system. Phagocytosis and opsonization of antigens. Cell mediated effecter responses. Lymphocyte migration, inflammation and Inflammatory responses. Hypersensitivity reaction. Autoimmunity, immune tolerance.

7. **Immunological techniques** 14 Hrs
   Antigen antibody reactions. Avidity and affinity. Specificity, cross reactivity. B cell activity measurement techniques (Ag-Ab reactions): Precipitation, Agglutination, Immunoelectrophoresis. Enzyme Immunoassays:Enzyme linked immunosorbent assay (ELISA), Radioimmunoassay (RIA), Immunofluorescence, Confocal Microscopy, Immunohistochemistry, Immunoblotting, and immunogold techniques. Production of monoclonal and polyclonal antibodies, Purification of antibodies. Immunoaffinity chromatography. T cell activity measurement techniques: Absolute lymphocyte count, DTH test, Fluorescence activated cell sorter (FACS). Therapeutics: Immunotherapy, Immunotoxins. Advances in Immunotechnology: Antibody engineering, Vaccinology.

1. **Plant Micro-Propagation Technique and Types of Culture** 10 hrs

Scope of plant biotechnology & application, role of in-vitro tissue culture in plant biotechnology. Types of in-vitro culture, Techniques of Micropropagation: Axillary buds proliferation, Regeneration Through meristem culture, callus culture, organogenesis and somatic embryogenesis. Production, preservation and use of somatic embryos as propagules. Artificial synthetic seeds production, Suspension culture: Cell culture, Protoplast isolation and culture. Types of cell culture (continuous, discontinuous and semicontinuous culture), automation technology and its application in tissue culture. Cryopreservation and germ plasm storage. Indexing for plant pathogens-Culture indexing for bacterial and fungal contaminant. Micropropagation of woody plant.

2. **Application of Tissue/Cell cultureTechniques** 8 hrs

Techniques of Meristem culture and in vitro grafting for the production of virus free plants. Pollen/ microspore culture for haploid plant production, use of haploids in plant breeding and mutation research. Techniques of Embryo culture and embryo rescue in agricultural and horticultural corps,Application of embryo culture in wide hybridization. Endosperm culture.Suspension culture in bioreactor:Secondary metabolite (medicinal and other commercial products) production, Biotransformation, economic aspects of in vitro production of secondary metabolite of plants.Induction of somaclonal variation, screening and its applications, Somatic hybridization and production of hybrids. Plant tissue culture as industry, Automation of micropropagation and industrial production of plantlets

3. **Mass scale production** 5 hrs

Molecular farming: novel proteins, carbohydrate and lipids production, enzyme production and Plant derived Vaccine. Culture in bioreactor: Principles and the technology, Carbohydrate and other economic chemicals production. Secondary metabolite production through cell cultures. Pharmaceutical & beverage production.
Single cell culture: media and techniques for algal culture, algae and cyanobacteria as source of nitrogen rich fertilizer, Single cell protein

4. **Genetic manipulation of plants** 15 hrs

Techniques of introducing DNA into plant cells: (10 hrs)
Marker and reporter genes used for plant transformation, Model plants and their Role in genetic manipulation, Indirect transformation: Genetic transformation of plant tissues with the use of Agrobacterium, Ti-plasmid and mechanism of T-DNA transfer (different protein involved and their role, vir region and other genes involved), Ti plasmid derived plant vector systems; binary and cointrigative vectors transformation process, regeneration of the transformed lines, Plant Viruses as biological vectors. Direct gene transfer methods in plants (Microprojectile bombardment, Electroporation; polyethylene glycol (PEG)- mediated gene transformation, Silica carbomfibres whiskers).
Transformation of protoplasts with naked DNA

5. **Genetically modified plant and their Application** (5hrs)

Genetic engineering for plant improvement: Development of Pest resistance, herbicide resistance, resistance against viruses, improving stress tolerance, Protoplast fusion and its implication, Importance of GM plants

6. **Plant developmental biology** 10 hrs

Life cycle of angiospermic plant, Developmental biology and morphogenesis in plants, Processes and molecular control mechanisms of different developmental stages: endosperm development, embryo development (radial and axil patterning), Seed and seedling development, dormancy, germination, vegetative growth (Pattern formation during Root and Shoot meristem development), Determination of leaf primordial and differentiation of leaf cells, Vegetative bud development, transition to reproductive growth, formation of floral organs and Floral development, senescence

Bioinformatics

1. **Bioinformatics Basic** 1hr

Introduction, Historical overview and Definitions, Bioinformatics Applications, Internet and search engines, database and database management system in bioinformatics

2. **Information Search and Data Retrieval** 4 hrs

Introduction, Tools for web search, Data retrieval Tools (Pubmed, OMIM, Sequences Databases for Nucleotide & Amino Acids, Gene Bank, Entrez, SRS Other Databases (Primary, Secondary, Subsidiary, Structural Databases) Data mining of Biological Data, File Formats, Genome & Organism specific Databases, Annotated Sequence Databases.

3. **Computational Method for Sequence alignment** 6 hrs

Local Alignment ( Smith-Watermann Algorithm), Global Alignment (Needleman Wunsch Algorithm), Alignment Matrices (Dot Plot, Substitution Matrices PAM & BLOSUM), Alignment with Gap Penalties, Multiple Sequence Alignment, Guide Tree, Application of Sequence alignment, FASTA, BLAST: Introduction, Types, Scores, E-values.

4. **Computational Approach for Phylogenetic analysis** 4 hrs

Introduction, Distances, Types of Trees, Tree construction Methods (Ultra metric Case, Neighbor Joining, Parsimony, MLH), Application of Phylogenetic Analysis, Elements of phylogenetic models

5. **Genomics** 5 hrs

Genome, Structural Genomics, Functional Genomics, Genome Mapping, sequencing (Next generation Sequencing), Comparative Genomics analysis, Large scale Genome analysis, Gene Prediction (Prokaryote & Eukaryote), Genome Annotation.

6. **RNA Structure analysis** 2 hrs

RNA Secondary Structure Predictions. Covarience Model-SCFG-based RNA profiles.

7. **Microarray Bioinformatics** 2 hrs

Sequence Databases for Microarrays, Computer Design of Oligonucleotide Probes, Image Processing, Analysis of Differentially Expressed Genes.

8. **Introduction to Basic Language and Algorithm** 2 hrs

Introduction to Perl, Introduction to Genetic Algorithm

9. **Structural Bioinformatics** 6hrs

Relationship of Protein three-dimensional Structure to protein Function, Evolution of Protein structure and Function, Obtaining viewing & analyzing Structural Data ( Rasmol, Chime, Cn3D), Structural alignment, Classification of proteins of known three dimensional Structures (CATH, SCOP), Homology Modelling.

Computer aided Drug Design: Introduction, Drug Design Approaches and Methods

Biophysical chemistry

1. **Description of Biological macromolecules**: 7hrs

Description of stoichiometry and geometry in macromolecules and structural complexity; description of configuration and conformation in macromolecules and their relation to small molecules; description of molecular interactions in macromolecules (strong and weak interactions and their distance and energy relationships); Cellular environment and role of water in defining macromolecular structure and biological function of macromolecules (solubility, hydrophobicity, membranes and transport across membrane; osmosis and osmotic pressure);

Symmetry and types of symmetry (mirror; rotational and translational) in macromolecules; Cartesian coordinate system and description of symmetry using simultaneous equations; application of symmetry elements to macromolecules at the molecular, monomeric unit and atomic level; hydropathy index of amino acids and partition coefficients, charge densities; amino acid abundance is proteins; protein sequences and their prediction; application of translational symmetry to polypeptide structure; Ramachandran's map and description of secondary structure in proteins; contact maps and description of secondary structure; supersecondary structure formation; description of 3D structure of proteins at the atomic level using translational symmetry; molecular graphics and their role in modeling macromolecular structure; brief description of quarternary structure of proteins with particular emphasis to symmetry and symmetry elements.

2. **Thermodynamics**: 4hrs

Heat, work and energy and molecular interpretation of thermodynamic quantities; entropy, free energy, and equilibrium.

3. **Molecular thermodynamics**: 3hrs

Complexities of macromolecular modeling and molecular mechanics; simulating macromolecular structure: molecular dynamic simulation and Monte carlo simulation.

4. **X-ray Crystallography** 4hrs

Atomic resolution, crystals, theory of X-ray diffraction; determination of crystal morphology and solving macromolecular structure by X-ray diffraction.

5. **Scan Electron Microscopy, Tunneling Microscopy** 2hrs

6. **Nuclear magnetic resonance (NMR)**: 3hrs

Theory and description of small molecular and macromolecular structure by NMR techniques

7. **Scattering from solutions of macromolecules** 2hrs

Light scattering concepts and measurements; Examples: X-ray, Neutron, and Raman scattering phenomenon.

Absorption, Emission and IR Spectrometry, linear and circular dichroism of biological polymers, Mass

8. **Spectrometry (Electron Spray, MALDI-TOF)** 7hrs

9. **Macromolecules in solution** 1hr

Equilibria and membrane potentials.

Metabolic biochemistry and secondary metabolites

1. **Introduction to metabolism** 2hrs

General characteristics of metabolic pathways: High energy compounds, Organic reaction mechanisms, Metabolic flux and coupled reactions; methods of investigation of metabolic pathways.

2. **Vitamins and coenzymes** 3 hrs

Classification. Role of vitamins, metals and other cofactors in enzyme function. Water soluble vitamins and their coenzymes: thiamin pyrophosphate, pyridoxal-5-phosphate, nicotinamide coenzyme, Flavin, Coenzyme A, lipoic acid, biotin, folate, ascorbic acid, cobalamine. Lipid soluble vitamins: Vit.A, Vit.D, Vit.E and Vit.K.

3. **Carbohydrate metabolism** 7hrs

Synthesis of carbohydrates (Tetrose, Pentose, Heptose, sucrose, glycogen, starch, cellulose), Pentose phosphate pathway, Digestion, absorption and mobilization of carbohydrates. Glycolysis reactions with emphasis on reaction mechanisms, feeder pathways of glycolysis, Gluconeogenesis, Citric acid cycle with emphasis on reaction mechanisms, Glyoxalate pathway, HMP pathway, ED pathway, fermentative pathways, electron transport chain (prokaryotic and eukaryotic), generation of ATP(Oxidative phosphorylation), glycogen metabolism. Regulation of carbohydrate metabolism.

4. **Lipid metabolism** 6 hrs

Digestion, absorption and mobilization of lipid in human. Synthesis and degradation of fatty acids, ketone bodies, triacyl glycerol, eicosanoids, phospholipids and glycolipids. Synthesis and utilization of cholesterol and cholesterol derivatives (bile acids, steroids hormones etc.) Regulation of lipid metabolism.

5. **Integration of metabolism**: 2 hrs

Integration of metabolic pathways, metabolic specialization of organs and hormonal regulation of metabolic pathways with emphasis on Insulin, glucagon, catachol amines.

6. **Nucleic acid metabolism** 2hrs

Synthesis, degradation and regulation of purine and pyrimidine nucleotides.

7. **Amino acid metabolism** 4 hrs

Digestion of proteins, absorption of amino acids. Transamination, deamination, urea cycle. Link between urea cycle and TCA cycle.

8. **Secondary Metabolism** 6 hr

Secondary metabolites of plants, animals and microorganisms. Importance of secondary metabolites, Main types of secondary metabolites

Phenolic metabolism: Structure functions and use of Phenolic compounds, Biosynthesis-shikimate/ aroginate pathway, biosynthesis of important phenolic compounds like coumarins, flavenoides, lignins, tannins, quinones

Isoprenoid metabolism: Mevalonic acid pathway and isopentenyl pyrophosphate synthesis. Structure, uses and biosynthesis of important terpens, steroids and carotenoides

Special nitrogen containing metabolites: Structure, uses and biosynthesis of amines, glycosides and alkaloides.