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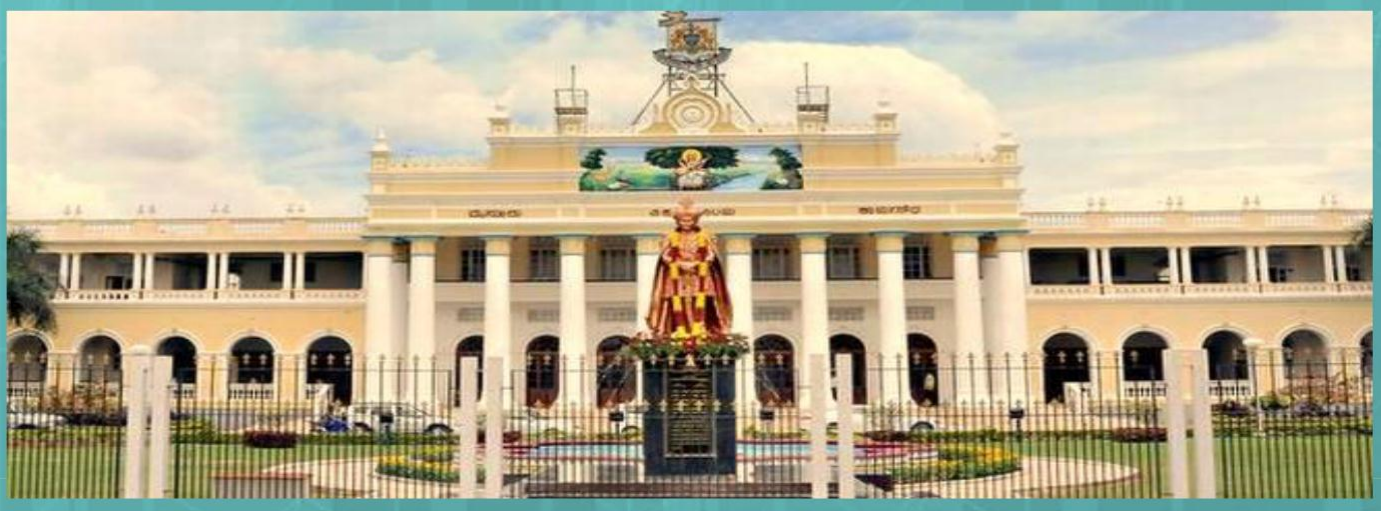
University of Mysore

(Estd.1916)

M.Sc. MOLECULAR BIOLOGY

Choice Based Credit System (CBCS)



UNIVERSITY OF MYSORE

Department of Studies in Molecular Biology
Manasagangotri, Mysuru-570006

Regulations and Syllabus
Master of Science in Molecular Biology (M.Sc.)
(Two-year semester scheme)

Under
Choice Based Credit System (CBCS)

Chairman
Board of Studies in Molecular Biology
University of Mysore
Manasagangotri, MYSURU-570 006
INDIA

UNIVERSITY OF MYSORE

GUIDELINES AND REGULATIONS
LEADING TO
MASTER OF SCIENCE IN MOLECULAR BIOLOGY

Programme Details

Name of the Department	: Department of Studies in Molecular Biology
Subject	: Molecular Biology
Faculty	: Science
Name of the Programme	: Master of Science in Molecular Biology
Duration of the Programme	: 2 years- divided into 4 semesters

Programme objectives

The main objective of this M.Sc., programme is to provide strong foundation in the subject Molecular Biology to become

- Teaching faculties in Academic Institutions.
- Researchers in research institutions or industries.
- Entrepreneur to start their own company.

Programme Outcomes

The M.Sc., programme in Molecular Biology is highly sought programme among life sciences in the University. On successful completion of this programme each student will:

- Have a strong foundation in understanding the basic biochemical reactions that occurs in both prokaryotic and eukaryotic systems at molecular level. Further the student will be able to learn cutting edge technology in the field of cell biology, molecular biology, microbiology, immunology and medicinal biology.
- Develop practical skills along with their theory components, which will help in their research programme both in academic institutions and in R & D programmes of industries.
- Inculcate skills for teaching in academic institutions for undergraduate and postgraduate students.
- Develop confidence in taking competitive examination in the field of life science both in India and abroad so that they can pursue higher education.

Programme Specific Outcome

1. Demonstrate an understanding of structure and metabolism of macromolecules and understand the regulation and disorders of metabolic pathways.
2. Gain proficiency in laboratory techniques in both biochemistry and molecular biology, and be able to apply the scientific method to the processes of experimentation and Hypothesis testing.
3. Acquire thorough knowledge in biochemical techniques, immunology, physiology and Biotechnology.
4. Learn to work as a team as well as independently to retrieve information, carry out Research investigations and result interpretations.
5. Develop the ability to understand and practice the ethics surrounding scientific Research.
6. Realize the impact of science in society and plan to pursue research.

Pedagogies employed in the M.Sc., programme

- Class room teaching will be using black board and chalk, power point presentation and information and communications technology.
- One on one interaction or with small student numbers during tutorial classes.
- Individual student performs experiments as per the protocol in practical classes.
- Student seminar/research paper presentation in each semester.
- Students will be tested for their writing abilities to answer precise and essay type questions.
- Every semester the students will be subjected to viva voce examinations by external examiners.
- Project work on a small research problem.
- Literature review in the form of Dissertation.
- Invited talks from eminent scientists.

PROGRAMME STRUCTURE

First Semester : Molecular Biology (Minimum 18 and Maximum 24 credits)

Sl. No.	Code	Title of the Paper	Course Type	Credit pattern			Total Credits
				L	T	P	
1	48751	Fundamentals of Chemistry	HC	3	0	0	3
2	48752	Separation Techniques	HC	3	0	0	3
3	48753	Analytical Techniques	HC	3	0	0	3
4		Practical-1: Techniques, and seminar	HC	0	2	4	6
5	48754	Essentials of Biomolecules	SC	3	0	0	3
6	48755	Basics of Microbiology	SC	3	0	0	3
7	48756	Animal Physiology	SC	3	0	0	3

Second Semester : Molecular Biology (Minimum 18 and Maximum 24 credits)

Sl. No.	Code	Title of the Paper	Course Type	Credit pattern			Total Credits
				L	T	P	
1	48761	Basics of Enzymology	HC	3	0	0	3
2	48762	Introduction to Molecular Biology	HC	3	0	0	3
3		Practical- 2: Restriction enzyme assays, seminar	HC	0	2	4	6
4		Dissertation	SC	0	0	2	2
5	48763	Carbohydrate and Lipid metabolism, and Bioenergetics	SC	3	0	0	3
6	48764	Protein and Nucleic acid metabolism	SC	3	0	0	3
7	48765	Plant Physiology	SC	2	0	0	2
8	48766	Genetic Engineering – Pros & Cons	OE	3	1	0	4

FIRST SEMESTER

HARD CORE

COURSE-I : FUNDAMENTALS OF CHEMISTRY

Objectives are:

- To study the fundamentals of chemistry of biomolecules.
- To study the molecular basis of organic reactions.

Course outcome
The student will:

- Understand the basic chemical bonds involved in the biomolecules and organic reactions
- Understand the stereochemistry of biomolecules and heterocyclic compounds.
- Understand the role of electrolytes and their importance in biological system.

Course Contents:

Bonding: Covalent bond; coordinate bond; coordinate bond formation in transition metals. Bonding of iron in hemologibin and cytochromes, cobalt in Vit B_{12}, magnesium in chlorophyll. Special properties of water; Structure and bonding. Crystal field theory; Ligand field theory and Valence bond theory. Chelators; types of ligands and complexes.

Electrolytes, Non-Electrolytes and Electrodes: Osmotic pressure, vapor pressure, osmometer, Donnan membrane equilibrium. Hydrogen electrode, electrode potential, and redox potential.

Stereochemistry: Importance of stereochemistry, position and order of groups around carbon. Geometric and optical isomerism; absolute and relative configuration. Symmetry view of chirality, relation between chirality and optical activity, representation of chiral structures by Fischer. Structure and stereochemistry of sugars and amino acids; anomer, epimer, diastereomer, sterioisomer, D and L, (+) and (-), R and S.

Mechanism of organic reactions: Intermediates and rearrangements in organic reaction. Reaction energetic. Classification of rearrangement reactions. Reaction rates, order and molecularity of reaction. Mechanisms and stereochemistry of substitution (electrophilic and nucleophilic - sN^1 and sN^2 reactions) addition, elimination and rearrangement reactions. Mechanisms of ester hydrolysis. Property of aromaticity and resonance.

Heterocyclic Compounds: Chemistry of furan, indole, thiazole, pterine, pteridine, isoalloxazine, pyrrole. Chemistry of porphyrins and heme and their biological importance.

Third Semester Molecular Biology (Minimum 20 and Maximum 24 credits)

Sl. No.	Code	Title of the Paper	Course Type	Credit pattern			Total Credits
				L	T	P	
1	48771	Advanced Molecular Biology	HC	3	0	0	3
2	48772	Cell structure and function	HC	3	0	0	3
3		Practical-3: Immunological and cloning techniques and seminar	HC	0	2	4	6
4	48773	Molecular Immunology	SC	3	0	0	3
5	48774	Omics and Bioinformatics	SC	3	0	0	3
6	48775	Microbial Technology and Bioprocessing	SC	2	0	0	2

Fourth Semester Molecular Biology (Minimum 20 and Maximum 24 credits)

Sl. No.	Code	Title of the Paper	Course Type	Credit pattern			Total Credits
				L	T	P	
1	48781	Recombinant Technology	HC	3	0	0	3
2		Pratical-4: Experiments in Molecular Genetics and seminar.	HC	0	0	4	4
3		Practical-5: Project Work	HC	0	0	6	6
4	48782	Molecular Genetics	SC	3	0	0	3
5	48783	Plant Biotechnology	SC	3	0	0	3
6	48784	Animal Biotechnology	SC	3	0	0	3
7	48785	Molecular basis of Evolution	SC	3	0	0	3
8	48786	Basics of Biostatistics	SC	2	0	0	2
9	48766	Genetic Engineering – Pros & Cons	OE	3	1	0	4

COURSE-II : SEPARATION TECHNIQUES

Objectives are:

- To study the basic principles involved in plant and animal cell culture technology.
- To study the various techniques involved in the separation of biomolecules.
- To study the advanced techniques in the analysis of biomolecules.

Course outcome

- Understand various animal models used in biology
- Understand cell fractionation techniques using different types of centrifugation methods.
- Understand the separation and characterization of biomolecules using different chromatographic, electrophoretic methods and blotting techniques.

Course Contents:

Preliminary techniques in Biochemistry: Animal and Plant models, choice of animals, types of studies, mutant organisms (auxotroph), animal and plant cell culture.

Microbial techniques: Isolation and culture of microorganisms - aerobic, anaerobic and facultative culture methods and preparation of culture media. Isolation of pure colony and its characterization. Staining - Gram stain, acid fast, endospore, flagella.

Cell fractionation techniques: Cell lysis, homogenization, extraction, salting in, salting out, dialysis and ultra filtration.

Centrifugation: Svedberg's constant, sedimentation velocity and sedimentation equilibrium.

Ultra centrifugation: Differential and density gradient centrifugation, centrifugal elutriation.

Chromatographic techniques: Principles and applications of paper, TLC, adsorption, ion exchange, gel filtration, affinity, GLC, chromatofocusing, HPLC and FPLC.

Electrophoretic techniques: Polyacrylamide gel electrophoresis, SDS-PAGE, 2D-electrophoresis, diagonal, agarose gel electrophoresis, isoelectric focusing, pulsed field electrophoresis, high voltage electrophoresis, capillary electrophoresis. Visualizing proteins, glycoproteisn, lipoproteins, and nucleic acids. Zymogram and reverse zymogram.

Blotting techniques: Dot blot, Southern, Northern, Western blot, DNA foot print assay, DNA finger print assay, gel retardation assay, nuclease protection assay. RFLP, RAPD.

COURSE-III : ANALYTICAL TECHNIQUES

Objectives are:

- To study the properties of biomolecules with the help of spectroscopic methods and their optimization.
- To study the characterization of biomolecules for their size, shape and structure using analytical techniques.
- To study isotopes and its application in understanding biological process.

Course outcome

- Understand the principles involved in different spectroscopic methods to analyze biomolecules.
- Understand different spectral analysis involved in determining the size, shape and structure of different biomolecules.
- Understand the different types of isotopes and its applications in biological reactions and pathways.

Course Contents:

Spectroscopic techniques: Principles of colorimeter, spectrophotometer, fluorimeter. Beer-Lambert's Law and its limitations. Extinction coefficient, fluorescent probes and their applications.

Physical methods of determining size, shape and structure of molecules:

Magnetic Resonance: NMR and ESR; principles and applications.

Vibration Spectra: IR and Raman; principles and applications.

Light Scattering: Determination of size and shape of macromolecules, Zimm's method.

Polarized Light: Plane and circularly polarized light, ORD and

CD and their applications.

X- ray Crystallography: Protein crystals, Bragg's law, unit cell, isomorphous replacement, fiber pattern of DNA.

Turbidometry, flame photometry, atomic absorption, spectrophotometry; instrumentation and applications.

Isotopes: Heavy isotopes and radio isotopes, theory and construction of mass spectrometer.

Electrospray Ionization, fragmentation, m/e, time of flight, MALDI and ESI. LC-MS, LC-MS-MS.

Radioisotopes in Biology: ^{3}H, ^{14}C, ^{32}P, ^{131}I, ^{35}S, concept of half-life, decay constant, detection and quantitation - GM counter and solid and liquid scintillation counter. Specific activity, autoradiography and their applications.

Applications of radioactivity: Labeling of proteins and nucleic acids, Dilution techniques, pulse chase method, carbon dating, substrate product relationship (cholesterol biosynthesis) and bond cleavage specificity.

COURSE-IV : TECHNIQUES AND SEMINAR

Objectives are:

- To develop skills in the practical components and 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.
- To develop skills for seminar presentation.

Course outcome

- Understand the basics of laboratory reagents/solutions and their preparations with respect to percent solution, molar and normal solutions.
- Understand the isolation and analysis of various biomolecules using spectroscopic methods.
- Understand the isolation and characterization of microorganisms using staining techniques.
- Develop the art of presentation during seminar which will help in developing skills for teaching profession.

Course Contents:

Preparation of buffer. Media preparation; nutrient broth, nutrient agar, potato dextrose agar, Czapekdox agar, Mac Conkey's agar.

Sterilization techniques, hot air oven, autoclave/pressure cooker, filtration unit.

Study of pure culture techniques: Serial dilution, pour plate, spread plate, streak plate, point inoculation.

Measurement of growth using -Turbidometer/ photocolorimeter/ spectrometer and Haemocytometer (Yeast cells)

Staining: Simple staining and negative staining, Differential (Gram's staining).

Observation of bacterial motility by hanging drop method.

Effect of disinfectants, antiseptics and antibiotics on the growth of microorganisms.

Preparation of cell homogenates; Prepration of chloroplast, mitochondria and nuclei.

Isolation of plasmid DNA Extraction of DNA and RNA from, Drosophila, coconut endosperm. Criteria of purity – 260/280 UV absorption ratio.

Colorimetry; applications of Beer-Lambert's law, determination of extinction coefficient. Colorimetric estimation of Nucleic aicd and proteins. Estimation of protein by Biuret and Lowry's methods.

UV absorption of protein and Nucleic acid. Hypo and hyper-chromicity of Nucleic acid on heat denaturation.

Estimation of sugar by DNS and anthrone methods.

Seminar: Each student will give a 15 min seminar with power point presentation on a topic assigned.

SOFT CORE

COURSES-5 : ESSENTIALS OF BIOMOLECULES Objectives are:

- To study the molecular properties of various biomolecules in the cell.
- To study structural characterization of biomolecules

Course outcome

- Understand the structure and classification of carbohydrates, amino acids, lipids proteins and nucleic acids.
- Understand glycobiology, protein folding, forces affecting protein folding.
- Understand the determination of amino acid composition, sequencing of DNA.

Course Contents:

Carbohydrates: Structure and classification of carbohydrates, monosaccharides, disaccharides and polysaccharides.

Chemistry of monosaccharides: Pentoses, hexoses, deoxysugars, amino sugars, muramic acid, neuraminic acid. Linkages in sucrose, lactose and maltose, trehalose and glycosides.

Chemistry of polysaccharides: Homopolysaccharides and heteropolysaccharides, starch, cellulose, glycogen, hyaluronic acid, chondroitin sulphate, chitin, xylans, bacterial cell wall polysaccharides, blood group polysaccharides.

Structure elucidation: degradation, graded acid hydrolysis, periodate oxidation, degradation of oxopolysaccharides, methylation, acetylation, GC-MS.

Glycobiology: Glycoproteins; Glycosidic bond, N- and O-glycosylation, lectins, carbohydrates in tissue engineering. Proteoglycans; agreecan, syndecan, and decorin. Pectin and pectic polysaccharides.

Aminoacids: Nomenclature, classification and buffering properties, zwitterionic structure, reaction of amino acids, unusual amino acids, non protein amino acids.

Peptide bond: Features of the peptide bond, naturally occurring peptides; glutathione, enkaphalins and endorphins. Chemical synthesis of peptides; solution phase synthesis, Merrifield's solid phase synthesis, and peptide ligation.

Determination of amino acid compositions: Acid and base catalyzed hydrolysis, separation, quantification, determination of N and C terminal residues, determination of site of glycosylation and type of linkage (o-glycosyl and n-glycosyl).

Elucidation of structure of proteins - Isolation of proteins; overview of purification and criteria of purity.

Determination of primary structure: Sequencing strategies; N-terminal and C-terminal, sequencing methods. Automated sequanators. Determiantion of s-s-bond position. Secondary structure of protein; α, β sheet, β bend, β turn and super secondary structures. Secondary structure prediction methods; Ramachandran plot, Chou and Fasman algorithm. Tertiary and quaternary structures.

Factors responsible for protein folding: Anfinsen's experiment. Weak forces of interaction; hydrogen bonding, Vander Waal's forces, London force, ionic interactions, hydrophobic interactions, S-S bridges, allolysine, peptide bond, protein modification – glycosidic, phosphate, acetylation, methylation, hydroxylation and prenylation. Denaturation and renaturation of proteins, molten globule. 3D Structure of myoglobin hemoglobin, immunoglobulin, collagen, chymotrypsin and keratin. Chaperons and Levinthal paradox.

Lipids: Classification of lipids; oils, fats, and waxes. Occurrence and properties of fatty acids, esters of fatty acids, cholesterol, phospholipids, glycolipids, sphingolipids, cerebrosides and gangliosides.

Nucleic Acids: Isolation of DNA and RNA from biological sources. Physiochemical properties of nucleic acids, melting of DNA, Tm; factors affecting Tm, Cot curve, classification of DNA based on cot curve. Chemical reactions of DNA and RNA.

Sequencing of DNA: Maxam Gilbert method, dideoxy method. Chargaff's rule, secondary structure of DNA. Watson and Crick model; B and Z DNA, other models of DNA structure. Secondary structure of tRNA and clover leaf model. Other secondary structural features in DNA, stem loop structure, palindromic sequences, cruciforms. DNA protein interaction; zinc finger, leucine zipper, helix-turn-helix, other motifs, DNA bending and kinks.

COURSE-VI : BASICS OF MICROBIOLOGY

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

- 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.

Course Contents:

Historical Aspects - Discovery of microorganisms. Theory of spontaneous generation. Era of Louis Pasteur. Microbes and fermentation. Microbes and diseases. Koch's Postulates. Recent developments in Microbiology. Branches of Microbiology.

General characteristics: morphology, nomenclature and classification of bacteria, yeast, molds, fungi, actinomycetes, rickettesiae and protozoa.

Techniques: Isolation and culture of microorganisms - aerobic and anaerobic culture methods, culture media. Isolation of pure colony, characterization. Staining - Gram stain, acid fast, endospore, flagella. Microscopy; simple, compound, phase contrast, fluorescent and electron microscopy.

Microbial Nutrition - Factors influencing growth, growth curve of bacteria. Measurement of growth, continuous culture, synchronous culture chemostat. Auxotrophs, autotrophs, heterotrophs, methods of cultivations and preservation of microorganisms.

Microbial Physiology: Growth, yield and characteristics, strategies of cell division, stress response.

Strain improvement methods: recombination using mutagens, protoplast fusion, r-DNA technology, selection of improved strains: Enrichment technique.

Methods of Control of Microorganisms: Bacteriostatic and bacteriocidal agents. Mechanisms of disinfection and sterilization. Physical and chemical methods.

Virology - Discovery of viruses, assay of viruses. Classification of viruses based on genetic material, structure of typical viruses - Bacteriophage T4, TMV, HIV. Bacteriophages as antibiotics.

Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells.

COURSE-VII : ANIMAL PHYSIOLOGY

Objectives are:

- To study different systems operating in a living organisms.
- To study the modern trends in reproduction and its corrective measures

Course outcome

- Understand the various systems and their physiological functions.
- Understand blood and its composition, nervous, respiratory, excretory, digestive, muscle and reproductive physiology.
- Understand the modern trends reproduction including invitro fertilization, artificial insemination and test tube baby.

Course Contents:

Introduction: Meaning and scope of animal physiology. Definition of cell types, tissue, organs and systems.

Circulatory system: Blood, composition, cells, plasma proteins and lipoproteins. Erythrocytes; shape and function. WBC; types, differential count and functions. Platelets and its function. Buffer systems, hemostasis, blood clotting, digestion of clot, anticoagulants, blood volume, blood pressure and their regulations. Plasma lipoproteins and their functions, HDL, LDL, VLDL, chylomicrons.

Nervous system: Structure of a neuron, nerve transmission, CSF; composition and function.

Respiratory System: Lungs, structure and functions, gas exchange, oxygen binding by hemoglobin, factors affecting oxygenation and acid-base balance.

Excretory System: Ultra structure of the nephron, glomerular filtration, formation of urine, acid - base balance.

Hepatobiliary System: Anatomy of the liver, blood supply, cells; hepatocytes, endothelial cells and Kupffer cells, secretory and excretory function and formation of bile.

Muscle physiology: Skeletal muscle and smooth muscle, muscle proteins; actin, myosin, tropomyosine, troponins.

Digestive System: GI tract, digestion and absorption of carbohydrates, proteins and lipids. Mechanism of HCI production in the stomach. Gastrointestinal hormones and role of pancreas in digestion. Basal metabolic rate (BMR), factors affecting BMR, specific dynamic action of foods.

Nutrition: Concepts of macro and micro nutrients, essential nutrients and their classification. Vitamins and minerals.

Thermoregulation : Effect of Temperature on biological system. Temperature relations of Poikilotherms and homeotherms, acclimation and acclimatization to cold and heat. Neuronal basis of thermoregulation.

Physiology of reproduction: Hormonal control of testicular and ovarian functions. estrous and menstrual cycle, implantation, gestation and partiurition. Modern trends in reproduction – Invitro fertilization, cloning, sperm bank, artificial insemination, test tube baby.

Adaptation : Adaptation to extreme environment - Desert, high altitude and salt tolerance.

SECOND SEMESTER

HARD CORE

COURSES-1: BASICS OF ENZYMOLOGY

Objectives are:

- To study general aspects of enzymes and its classification.
- To study the molecular mechanisms of enzyme reactions using inhibitors and activators.

Course outcome

- Understand enzymes, their activity measurements and kinetic reactions.
- Understand enzyme reactions using inhibitors and activators.
- Understand the nature of catalysis, mechanism of action and type of inhibition.
- Understand the regulation of enzymes in metabolic reactions.

Course Contents:

General aspects: Nature of enzymes, localization, isolation, purification and characterization of enzymes. Criteria of purity of enzymes, fold purity. Nomenclature and IUB classification of enzymes. Enzyme specificity, specific activity, assay methods; coupled enzyme assays, continuous, end point and kinetic assay. Units of enzyme activity, IU and Katal.

Enzyme kinetics: Michaelis-Menten equation for uni substrate reactions, initial velocity approach, steady state approach. Vmax, Km and their significance. Linear transformation of Michaelis-Menten equation; Lineweaver-Burk plot, Eadie-Hofstee, Wolf and Cornish-Bowden. Scatchard plot.

Rate of a reaction, order and molecularity. I order reaction kinetics. Rectangular hyperbola, Michaelis-Menten equation as rectangular hyperbola, linear transformation, calculation of slope, intercept.

Inhibition: Reversible and irreversible inhibition; competitive, non competitive, uncompetitive product inhibition and suicide inhibition.

Determination of Ki and Kd.

Bisubstrate reaction: Cleland's notation with examples of ordered, ping-pong, and random reactions. General rate equation.

Cooperativity: Binding of ligands to macromolecules; Scatchard plot, positive and negetive cooperativity. Oxygen binding to hemoglobin. Hill equation, homotropic and heterotropic effectors, aspartyltranscarbamylase as an allosteric enzyme

Mechanisms of enzyme catalysis: Active site structure; methods of determining active site structure. Isolation of ES complex, affinity labeling, chemical modification studies, site directed mutagenesis.

Nature of enzyme catalysis: Transition state theory, proximity and orientation, orbital steering, acid base catalysis, covalent catalysis, metal ion catalysis, nucleophilic and electrophilic catalysis, intramolecular catalysis, entropy effects. Effect of temperature and pH on enzyme catalysed reaction.

Mechanisms of action of specific enzyme: Chymotrypsin; zymogen activation, acid-base catalysis, charge relay net work. Lysozyme, alcohol dehydrogenase, ribonuclease, carboxypeptidase A, RNA as an enzyme, abzymes, coenzymic action of NAD^+, FAD, TPP, PLP, Biotin, CoA, folic acid and lipoic acid.

Isoenzymes; LDH, multifunctional enzymes (DNA polymerase) and multi enzyme complex (PDC).

Metabolic regulation of enzyme activity: Feedback regulation, fine control of enzyme activity. Fast reactions - Stopped flow, temperature jump method with examples of enzymes.

COURSE-II : INTRODUCTION TO MOLECULAR BIOLOGY Objectives are:

- To study the basics of molecular biology.
- To study the molecular mechanism involved in the storage and transfer of genetic information from one generation to next generation.

Course outcome

- Understand the historical discovery made and the methodology employed to establish that DNA is the genetic material.
- Understand the molecular process of transcription, translation process while transferring genetic information from DNA to protein via RNA molecules.
- Understand the importance of posttranslational modifications in the regulation of cellular events.

Course Contents:

Introduction: Historical perspective, composition of RNA and DNA. Bases, Chargaff s rule. Types of RNA. Isolation and purification of RNA and DNA, structure of RNA and DNA, central dogma of molecular biology.

DNA-antiparellel nature: Nearest neighbour base frequency analysis. Replication of DNA, semi conservative nature; Messelson and Stahl experiment. Replication of double stranded DNA, direction of replication, discontinuous replication, Okazaki fragements. DNA polymerase I II and III, DNA ligase, DNA topoisomerases. Fidelity of replication, replication in viruses, rolling circle model, single stranded DNA virus. Applications of mitochondrial DNA. Trombon model, translesion synthesis (DNA pol IV and V).

Transcription: Colinerity of genes and proteins, RNA polymerase I, II and III. RNA biosyntehsis in prokaryotes and eukaryotes; initiation, elongation and termination. RNA dependent RNA synthesis, RNA replicase of Qβ virus. Processing of eukaryotic RNA, cap addition, poly A tail addition, RNA editing. Processing of tRNA and mRNA transcripts.

Translation: Genetic code, triplet codon, universality features of the genetic code, assignment of codons, studies of Khorana, Nirenberg, triplet binding techniques, degeneracy, wobble hypothesis, evolution of genetic code and codon usage, variation in the codon usage.

3D structure of prokaryotic and eukaryotic ribosomes, ribosomal protein synthesis; initiation elongation and termination. Role of mRNA and tRNA. Aminoacyl tRNA synthesis and its role in translation accuracy.

Post translation modification of proteins, signal cleavage, disulphide bond formation, O and N-glycosylation, folding of nascent protein, role of chaperones, attachment of glycosyl anchor, and other modifications.

Enzymes in DNA and RNA degradation: Nucleases, ribonucleases, classification and role.

COURSE - 3: ENZYME ASSAYS AND RESTRICTION DIGESTION,

SEMINAR Objectives are:

- To develop skills in the practical components and to learn good laboratory practices
- To perform enzyme catalyzed reactions.
- To perform restriction digestion of plasmid DNA.
- To prepare *E. coli* competent cells and their transformation.

Course outcome

- Understand the kinetics of enzyme catalyzed reactions.
- Understand restrictions enzyme digestion of plasmid DNA and its importance molecular biology.
- Understand the preparation of competent cells and their applications in molecular biology.
- Develop the art of presentation during seminar which will help in developing skills for teaching profession.

Course Contents:

Enzymes: Salivary Amylase, and Esterase from Pea extract.

Specific activity, pH and temperature optimum, energy of activation, Km and Vmax. Photo-oxidation of methylene blue. Photosynthetic reduction of 2,6 dichlorophenolindophenols.

Preparation of E.coli Competent cells using magnesium chloride method, Transformation of plasmid DNA in E.coli and yeast.

Restriction digestion of plasmid DNA, Electrophoresis of DNA and RNA.

Transformation, identification by antibiotic resistance and chromogenic substrate.

Seminar: Each student will give a 15 min seminar with power point presentation on a topic from the subjects assigned.

SOFT CORES

COURSES -4: DISSERTATION

Objectives are:

- To study and consolidate a research problem by collecting the available research data.

Course outcome the student will:

- Be trained to review literature of a research problem.
- Understand the research problem so that one can plan for future course of the research work.

Course Contents:

Students will be assigned/they will select a recent topic on which they will write a review and submit in the form of a booklet for evaluation.

COURSE-V: CARBOHYDRATE AND LIPID METABOLISM, AND BIOENERGETICS

Objectives are:

- To study different aspects of catabolism, anabolism and amphibolic pathways of carbohydrate and lipid metabolism.
- To study the laws of thermodynamics and synthesis of high energy compounds in the cell and energy utilization.

Course outcome

- Understand the common metabolic pathways of carbohydrates and lipids.
- Understand the hormonal regulations of catabolism and anabolism.
- Understand the mechanism of electron transport chain and its importance in ATP production.

Course Contents:

Introduction - Catabolism, anabolism, catabolic, anabolic and amphibolic pathways.

Carbohydrates: Cellular ingestion of glucose, glycolysis, energetics regulation. Pathways of utilization of pyruvate-lactate, ethanol, gluconeogenesis, regulation, Cori cycle, glucose paradox, citric acid cycle its regulation, energetics, anaplerosis, glyoxylate cycle.

HMP shunt pathway, interconversion of hexoses. Utilization of non glucose sugars. Biosynthesis of sucrose, starch and glycogen.

Lipids: Degradation of triacylglycerols, phospholipids and sphingolipids and regulations; Fatty acid degradation; β-oxidation Knoop's experiment, saturated and unsaturated fatty acids.

Regulation, α and ω oxidation. Energetics and biosynthesis of fatty acids; fatty acid synthetase complex, chain elongation and desaturation. Pathways in plants and animals, conversion of linoleate to arachiodnante.

Cholesterol synthesis and degradation and regulations: Metabolism of circulating lipids; chylomicrons, HDL, LDL and VLDL. Reverse cholesterol transport by HDL.

Phospholipid biosynthesis and regulations: Denovo pathway and inter conversion, biosynthesis of phospholipids, sphingolipids, ether lipids and glycolipids. Biosynthesis of prostaglandins, thromboxanes leukotrienes.

Integration of metabolic pathways: Integration of carbohydrate and lipid metabolism, and their regulation and manipulation.

Thermodynamics: I, II and III laws of thermodynamics. Enthalpy, entropy, free energy and chemical equilibrium.

High energy compounds: Energy currency, ATP, ADP, creatine phosphate, phosphoenol pyruvate as energy rich compound

Mitochondrial electron transport: Entry of reducing equivalents for oxidation; malate-aspartate shuttle, glycerol phosphate shuttle.

Organization of respiratory chain complexes, structure and function of the components; Fe-S proteins, cytochromes, Q cycle, proton transfer, P/O ratio, respiratory control, oxidative phosphorylation, uncouphers and inhibitors, sequence of electron carriers based on red-ox potentials.

ATP synthesis, ATP synthase complex, binding change mechanism, proton motive force, Mitchell's hypothesis.

Substrate level phosphorylation, futile cycles and their application.

COURSE-VI : PROTEIN AND NUCLEIC ACID

METABOLISM Objectives are:

- To study the general pathways involved in protein degradation
- To study amino acid metabolism and its inborn errors.
- To study the metabolism of nucleic acids and its associated disorders.

Course outcome

- Understand biosynthesis and degradation of proteins, glycoprotcsins, proteoglycans, heme and porphyrins.
- Understand biosynthesis of non-ribosomal synthesis of peptides and physiological active amines.
- Understand general mechanism of amino acid metabolism, intermediate metabolism and its regulations in microorganisms, plants and animals.

- Understand the detailed synthesis and degradation of purines and pyramidines pathways and their disorders.

Course Contents:

Proteins: General mechanisms of degradation in cells; ubiquitin-proteosome pathway, lysosomal pathway.

Degradation and biosynthesis of glycoproteins and proteoglycans.

General mechanisms of amino acid metabolism and regulations: Role of cofactors; PLP and THF in amino acid metabolism. Deamination, transamination, decarboxylation desulphuration process.

Degradation and biosynthesis of individual ammo acids. Aliphatic, aromatic, and branched chain amino acids.

Differences in the pathways in microorganisms, plants and animals.

Regulation of amino acid biosynthesis; transglutaminase cycle, urea cycle.

In born errors of amino acid degradation; PhenylKetonuria, alkaptonuria, maple syrup urine.

Purines and pyrimidines: Pathways of degradation of nucleic acids, purines and pyrimidines, uric acid formation. Salvage pathways, de novo biosynthetic pathways and regulations.

Gout and Lysch-Nyhan syndrome. Conversion of nucleotides to deoxynuclotides. Mchanisms of action of methotrexate, 5-fluorouridine, azathymidine.

Biosynthesis of cofactors: NAD^+, FAD and coenzyme A, polyamine biosynthesis and their metabolic role.

COURSE-VII: PLANT PHYSIOLOGY

Objectives are:

- To study major biochemical reactions in plant system.
- To study secondary metabolites and their role in host parasite interaction.

Course outcome

- Understand the harvesting solar energy to chemical energy by photosynthesis, solute transport and photo assimilate translocation process
- Understand nitrogen metabolism and various plant hormones in different stages of plant development.
- Understand various phytochemicals as secondary metabolites and their role in plant defense system.

Course Contents:

Photosynthesis: Photosynthetic apparatus in plants, photosystems I and II, light harvesting antenna complex.

Electron flow and photophosphorylation; cyclic and noncyclic, oxygen evolution, Calvin cycle. C3, C4 and CAM cycle. Photorespiration, bacterial photosynthesis. Regulation of photosynthesis. RUBISCO.

Nitrogen metabolism: Importance of nitrogen in biological systems, nitrogen cycle. Nitrogen fixation; symbiotic and nonsymbiotic, nitrogenase complex, energetics and regulation. Formation of root nodules in legumes. Assimilation of nitrate and ammonium ion.

Plant hormones: Biosynthesis, storage, breakdown and transport. Physiological effects and mechanisms of action of auxines, gibberlines, cytokinins, ethylene, abscisic acid.

Sensory photobiology: Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins, stomatal movement, photoperiodism and biological clocks. Seed dormancy, inception of germination. Germination and growth regulators, juvenility, vernalization.

Solute transport and photo assimilate translocation: Uptake, transport and translocation of water, ions, solutes and macromolecules from soil through xylem and phloem. Transpiration, mechanisms of loading and unloading of photoassimilates.

Phytochemicals: Extraction, fractionation and characterization.

Secondary metabolites - Terpenes, phenols, flavonoids and nitrogenous compounds and their roles in plant physiology and as alternative medicine.

Stress physiology: Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses; mechanisms of resistance to biotic stress and tolerance to abiotic stress.

Host parasite interaction: Recognition and entry processes of different pathogens like bacteria, viruses, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in plants, cell-cell fusion in both normal and abnormal cells and defense system in plants.

OPEN ELECTIVE

COURSE- 1: GENETIC ENGINEERING

- To study the basics cellular structure of prokaryotes and eukaryotes.
- To study the basic aspects of central dogma of molecular biology.
- To study the outcome of human genome project.
- To study genetically modified foods and their usage.

Course outcome

- Understand general aspects of central dogma of molecular biology.
- Understand the human genome project and genetic disorders.

- Understand the significance of genetically modified food.
- Understand the importance of pharmaceutically important biomolecules.

Course Contents:

Cell structure and subcellular organells and their function. Origin of mitochondria and chloroplast. Prokaryotes and eukaryotes.

DNA and RNA as Genetic materials. Central Dogma of Molecular Biology.

Work of Watson and Crick, Rosalind Franklin, Chargaff, Hershey and Chase, Stahl and Messelson, Kornberg, Khorana, Barbara Metchinkof.

Gene-polypeptide concept. Cistron, mono, poly. Genes and gene families.

Coding and Non coding DNA, jumping genes.

Human genome project and its reality. Gene libraries of important

organisms. Chromosomal basis of Genetic disorders. Sickel cell anemia,

Thalasemea, Cancer at genetic level – acquired and inherited.

Genetically modified foods. Golden rice, BT Cotton and Brinjal,

Development of resistant variety crops, Seed less fruits, Hybrid variety fruits and vegetables.

Pharmaceutical Applications: Production of Insulin, Antibodies, vaccines.

THIRD SEMESTER

HARD CORE

COURSE-I:ADVANCED MOLECULAR BIOLOGY Objectives are:

- To study basics of genome organization in prokaryotic and eukaryotic system.
- To study the regulation of prokaryotic gene expression.
- To study the regulation of eukaryotic gene expression at different levels.

Course outcome :

- Understand the genome organization and complexity in both prokaryotes and eukaryotes.
- Understand prokaryotic gene expression at molecular level.
- Understand eukaryotic gene expression regulation at the level of DNA structure, transcription, translation and posttranslational modifications.

Course Contents:

Gene structure: Structural organization of prokaryotic and Eukaryotic gene. Complexity of gene.

Regulation of gene expression in prokaryotes: Operon model; lac operon, structure and regulation. Galactose operon; role of two promoters. Arabinose operon; positive control. Tryptophan operon; T attenuation control.

Eukaryotic gene regulation: Regulation of gene expression at the level of DNA structure; super coiling, DNA methylation. Role of nucleosome structure in enkaryotic gene expression; glucocorticoid gene, DNA kinking, bending and gene regulation. Chromatin structure, chromatin remodeling, Swi/Snf, remodeling assay, ChIP.

Regulation at the level of transcription: Transcription factors, TF II, NFkB, regulation of NFkB and its activation. Formation of initiation complex. Role of enhancer.

Regulation at the level of RNA processing: RNA export and RNA stability, factors affecting RNA stability and RNA degradation.

Regulation at the level of translation: Secondary structure in the 5' and 3' untranslated region; regulation of ferretin and transferring, mRNA. Role of upstream AUG codons. (GCN 4 gene regulation), transplanting and translational introns, protein splicing inteins.

Role of aminoacyl t-RNA synthetase in the regulation of accuracy of translation, proof reading mechanism. Ribosomal optimization of translation. Regulation at the level of ribosome assembly.

DNA binding protein motifs: Zinc finger, leucine zipper, helix-turn-helix and other motifs.

Regulation at the level of post translational modification: proteins stability, N-end rule, PEST and other sequences, unbiquitin mediated degradation.

COURSE-II : CELL STRUCTURE AND FUNCTION Objectives are:

- To study the basic components of a cell, cell cycle and its regulation.
- To study endocrine systems and their regulations.
- To study the mechanism of actions of different classes of hormones.

Course outcome :

- Understand the detailed structure and function of a cell and their regulation by cyclins and CDKs.
- Understand the various endocrine organs in relation to the regulation of various metabolic processes.
- Understand the various signaling cascades in regulation of cellular metabolism.
- Understand the hypo and hyperactivities of all the endocrine organs and their manifestation in various disorders.

Course Contents:

Cell: Structure of a cell, mitosis, meiosis, cell cycle and its regulation, different phases of cell cycle. Apoptosis, cyclins and CDKs. Cell-cell and cell-ECM interaction and ECM structure.

Endocrine System: Endocrine organs in man. Location and inter relationship of endocrine glands in man; classification and chemistry of hormones, hormones of hypothalamus, pituitary, thyroid, parathyroid, pancreas, liver, adrenals, gonads and intestine.

Functions and abnormalities: Hypo and hyper production of hormones secreted by; pituitary, thyroid, pancreas, adrenals and gonads.

Structure and control of hypothalamus function: Hormones produced; GRH, somatostatin, TRH, CRH, GnRH.

Pituitary gland: Structure, hormones of anterior, posterior and median lobes. Pro-opiomelanocortin.

Testes and ovaries: Structure, hormones produced by testes and ovaries, menstrual cycle.

Regulation of hormone production and release: hypothalamus-pituitary-target organ axis and regulation by feedback mechanism. Conversion of cholesterol to steroid hormone.

Mechanism of action of peptide hormones: General mechanisms of cell signaling by hydrophilic factors, transmembrane receptors, transmembrane receptors, G protein coupled receptors, receptor tyrosine kinase, eicosanoid receptors.

Isolation and characterization of insulin receptor.

Mechanism of action of steroid hormones: Steroid receptors, isolation and characterization of steroid receptors. Receptor down regulation, desensitization and up regulation.

Second messengers: IP_3, DAG, cAMP, protein kinases. Nitric oxide signaling; generation and action.

Growth factors: Structure, mechanism of action and receptors of EGF, PDGF, NGF and IGF.

Pineal gland, melotonin and circadian rhythm.

Chemistry and action of prostaglandins, prostacyclins and thromoxanes.

Newly discovered hormones.

Insect hormones: Structure and function of moulting hormone, ecdysone, juvenile hormones, Pheromones, communication in insects.

Application of insect hormones.

COURSE-III : PRACTICAL-3: EXPERIMENTS IN IMMUNOLOGY AND CLONING TECHNIQUES AND SEMINAR

Objectives are:

- To develop skills in the practical components and to learn good laboratory practices
- To isolate immunoglobulins from chicken egg yolk and perform immunological assays.
- To learn primer design, PCR and cloning strategies.
- To develop skills for seminar presentation.

Course outcome :

- Understand the structure and characteristics of immunoglobulins using various immunological techniques.
- Understand the strategies involved in designing primer, performing PCR and cloning.
- Develop the art of presentation during seminar which will help in developing skills for teaching profession.

Course Contents:

Isolation of IgG from egg yolk and from Serum. ELISA and Western Blot analysis of expressed proteins.

Primer Design, PCR, Reverse Transcribed PCR, Protein Electrophoresis.

RFLP, RAPD.

Cloning Strategies; Sticky and blunt end ligation, Identification of clone.

Auxotrophes. Complementation.

Protein expression in E.coli / Yeast host system.

Cloning of a gene from Yeast / Drosophila / Plant Genome.

Seminar: Each student will give a 15 min seminar with power point presentation on a topic from the subjects assigned.

SOFT CORE

COURSE-IV : MOLECULAR IMMUNOLOGY

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 employment to diagnose disorders.

Course outcome :

- 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.

Course Contents:

Introduction: Historical development and milestones in immunology. Definitions; antigenicity, immunogenicity, innate and acquired immunity. Primary and secondary lymphoid organs, self and non self discrimination. Antigens and antibodies; haptens and determinants epitopes and paratopes. Antigenicity, carbohydrates, proteins, nucleic acids, and cells as antigens. Valency of antigen, epitope analysis.

Classes and subclasses of immunogloblins, structure of immunoglobulins, hyper variable region isotypic, allotypic and idiotypic variation.

Cellular Basis of Immunity: Primary and secondary immune response. Reticuloendothelial system, B and T and accessory cells. Development of B and T cells. Sub sets of B and T cells. T-helper cells, T-killer cells, T-suppressor cells. B and T cell receptors, antigen processing and presentation. B and T interaction. Cytokines and co-stimulatory molecules; lymphokines, interleukins, structure and function of IL-lβ, IL-2, TNFα. Suppression of immune response, immunoglobulin genes, generation of immunoglobulin diversity, gene rearrangement and other mechanisms, clonal selection theory of Burnet.

MHC: MHC gene and its polymorphism, role of MHC in immune response and transplantation.

Non-specific defenses in man: Barriers to infection; skin, mucous membrane, inflammation, complement hyper sensitivity reactions (Type I, II, III and IV).

Transplantation: Autograft, isograft, allograft and xenograft. Graft rejection, graft vs. host reaction. Immunosuppressive drugs.

Tumour immunology: Tumour associated antigens, factors favoring tumour growth, immune surveillance. Tumour necrosis factor α and β. Antitumour drugs.

Disorders of immunity: Immunological tolerance, auto immune disorders, AIDS, SCID.Systemic Lupus Erythomatosus.

Vaccines: Adjuvants, vaccines and their preparations. Polyclonal and monoclonal antibodies; hybridoma technique.

In vitro antigen-antibody reaction: Precipitation, agglutination, complement fixation, immuno diffusion, immunoelectrophoresis, immunofluorescence, RIA, ELISA.

COURSE-V : OMICS AND BIOINFORMATICS - 3 CREDITS

Objectives are:

- To study the basics of genomics, proteomics through bioinformatics.
- To study various data bases and servers involved.
- To study molecular modeling and drug designing.

Course outcome :

- Understand the biological databases and related software employed to analyze DNA and protein sequences.
- Understand the generation and prediction of different molecular structural modeling from the available data.
- Understand molecular phylogenetic based on the existing sequence data.
- Understand proteomics and sequence analysis using various software.
- Understand designing a drug and its interaction with the ligands.

Course Contents:

Introduction to Genomics: DNA isolation, sequencing by dideoxy method and next generation sequence analysis. Hybridization methods, microarray analysis, and reverse transcribed and real time PCR.

Biological databases: Introduction, classification of biological databases, retrieval of biological database systems. Molecular Modeling Database at NCBI, Molecular visualization software (RASMOL). Phylogenetics Clustal. Prediction of genes (Gene finder, ORF finder).

Sequence comparison and database search: Introduction, pair wise alignment, global alignment, local alignment, multiple sequence alignment.

Scoring a multiple alignment, multiple sequence alignment, methods-dynamic programming approach, progressive alignment, iterative refinement methods. Pattern matching in DNA and protein sequences, PAM matrices, BLAST, FAST and FASTA. Nucleotide sequence analysis, tools and methods, single nucleotide polymorphism.

Molecular phylogenetics: Introduction, application of phylogenetic trees, basic terminology, taxa, taxanomy, root, leaf, node, tree, branch, clade, dendogram, cladogram, rooted tree, unrooted tree, scaled tree. Phylip, Clustal.

Introduction to proteomics: Analytical methods of protein and peptide separations, protein digestion techniques, Mass spectrometers for protein and peptide analysis. Protein identification by peptide mass fingerprints, peptide sequence analysis by tandem mass spectrometry.

Protein sequence analysis using softwares; Emboss, data mining proteomes, motif mapping using prosite, prodom, protein expression profiling, protein-protein interactions, protein complexes. Mapping protein modifications. Protein secondary structure analysis, Molecular visualization, protein 3D structure using Rasmol, pdb file format.

Protein and secondary structure prediction: Secondary structure prediction methods, softwares for secondary structure prediction, protein families and classification, prediction of transmembrane regions. CATH and SCOP.

Protein modeling: Introduction, methods of protein modeling, homology or comparative modeling, model refinement, evaluation of the model.

Molecular modeling: Concepts of Molecular Modeling, molecular structure and internal energy, energy minimization of small molecules, *Ab initio*, and semi-empirical methods, Construction of initial model, refining the model, manipulating the model, three-dimensional structure prediction, comparative modeling, homology modeling, threading, energy based prediction of protein structures, modeling software.

Introduction to drug designing: In silico analysis, physico-chemical property prediction, aqueous solubility, Lipinski's rule of five.

Docking methods: Three dimensional descriptions of binding site environment and energy calculation, automatic docking method. Three dimensional database search approaches, design of ligands, drug-receptor interactions, automated structure construction methods, AUTODOCK.

COURSE-VI:MICROBIAL TECHNOLOGY AND BIOPROCESSING TECHNOLOGY

Objectives are:

- To study industrial importance of microorganisms and their metabolites.
- To study the process of fermentation in the production of biomolecules.
- To study the process of production of pharmaceuticals by genetically engineered microbial cells.

Course outcome :

- Understand the importance of microorganisms and their metabolites in medicine.
- Understand the important applications of fermentation and genetically engineered microbial cells in the production neutraceuticals and pharmaceuticals.

Course Contents:

Industrially Important Microorganisms: Development, Growth cycle, effect of nutrients, energetic of growth, growth rate and cell cycle.

Metabolites: Primary and secondary metabolites.

Fermentors and Bioreactors: Fermentor; stirred fermentor, microcarrier, Batch culture. Bioreactors; control systems, operation, optimization, control and monitoring of variables such as temperature, agitation, pressure, pH, online measurements and control, use of biosensors in bioreactors.

Downstream processing of metabolites: Separation of cells, foam and flocculation. Disintegration of microorganisms, mechanical and enzymatic methods. Filtration; plate filters, rotary vacuum filter, membrane filtration, ultra filtration and reverse osmosis.

Centrifugation, chromatographic techniques, absorption, spray drier, drum dryers, freeze dryers.

Microbial products: Microbial production of vitamins, enzymes, organic acids, amino acids, polysaccharides, antibiotics, ethanol, biosurfactants.

Drug development and pharmaceutical process: Production of pharmaceuticals by genetically engineered cells (hormones, interferons), microbial transformation for production of important pharmaceuticals (steroids and semi-synthetic antibiotics), new generation antibiotics, protein engineering, drug design, drug targeting Nanotechnology.

FOURTH SEMESTER

HARD CORE

COURSE-I : RECOMBINANT TECHNOLOGY Objectives are:

- To study the basics of recombinant DNA technology.
- To study the applications of various plasmids/vectors and PCR technique in cloning.
- To study the importance and applications of transgenic animals and plants.

Course outcome :

- Understand the principle and methodology employed in DNA recombinant technology.
- Understand the various plasmids/vectors in cloning.
- Understand the importance of restriction enzymes and ligation enzymes in the process of cloning.
- Understand the applications of transgenic animals, plants, gene therapy and their negative impact.

Course Contents:

Genetic Engineering: Extraction and purification of nucleic acids (DNA and RNA) from biological sources. Definition, aims and objectives of recombinant DNA technology.

Restriction-modification systems, restriction enzymes; type I, II and III, specificity, sticky ends and blunt ends, isoschizomers. Gene cloning; genomic cloning, shot gun cloning, cDNA cloning.

Vectors: Plasmids, phage, cosmids and phagemid. Yeast cloning vectors, plant vectors, bacterial artificial chromosome, SV40, shuttle vectors, construction of expression vectors.

Ligation: Blunt end and sticky end ligation, use of linkers and adopters, homo polymer tailing, colony hybridization, plaque hybridization.

Transformation: Micro injection, electroporation, lipofection, calcium phosphate method, protoplast fusion/somatic cell hybridization and biolistic methods.

Transgenic plants and animals, gene knock out.

Techniques: DNA sequencing, shot gun and orderly sequencing, chromosome walking, PCR; analysis of products, nested PCR, applications of PCR in cloning, agriculture and medicine. RT-PCR technique and applications. Real time PCR for quantification.

Identifying the right clones: Direct screening; insertional inactivation of marker gene, visual screening, plaque phenotype. Indirect screening; immunological techniques, hybrid arrest translation, hybrid select translation. Screening using probes; construction of gene probes, hybridization and labeling.

Mapping in Prokaryotes and Viruses: Bacterial transformation and transduction, conjugation; F+ plasmids, Hfr cells, time of entry mapping. Arrangement of genes in phage chromosome, plaque formation and lytic cycle. Fine structure of rII locus of T4. Lysogeny and λ phage.

Applications: Gene therapy, applications in agriculture medicine, industry. GM foods, terminator gene, negative impact of genetic engineering.

COURSE-II: PRACTICAL -4: EXPERIMENTS IN MOLECULAR IMMUNOLOGICAL TECHNIQUES AND GENETICS AND SEMINAR.

Objectives are:

- To study the phenotype using Drosophila as a model organism.
- To study the chromosomal aberration using Giemsa staining.

Course outcome the student will:

- Understand the genetic variation in phenotypic observation
- Understand the applications of chromosomal staining.

Course Contents:

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

COURSE-III : PRACTICAL - 5: PROJECT WORK

Objectives are:

- To address a small research problem.
- To design, perform and interpret the results.

Course outcome the student will:

- Understand designing experiments based on the research problem.
- Understand compiling and analyzing of data.
- Be able to write a comprehensive project report.

Course Contents:

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.

SOFT CORE

COURSE-IV : MOLECULAR GENETICS - 3 CREDITS

Objectives are:

- To study the basics of genetics and regulations of genetic materials.
- To study chromosomal aberrations, repair mechanisms and genetic disorders.

Course outcome the student will:

- Understand the early genetic work from Mendelian laws up to recent molecular study of genetic principles.
- Understand the various aberration processes and the repair mechanism.
- Understand the regulations of gene in both prokaryotes and eukaryotes.
- Understand the genetic disorders.

Course Contents:

Basic Principles of Mendelism: Laws of inheritance, dominance, codominance, epistasis, (coomb shape in chickens) pleiotropism. Cytoplasmic inheritances (male sterility in plants, shell coiling).

4 h

Gene linkage and chromosome: Linkage and recombination of genes in a chromosome. X-linked inheritance. Polygenic inheritance, mitochondrial inheritance, Y-chromosome inheritance. Map unit.

Chromosome number: Ploidy, Karyotyping, sex chromosome and dosage compensation. Mobile genetic elements.

Organisation of genes in prokaryotic and eukaryotic Chromosome: Genome size and evolutionary compplexcity, C-value paradox.

structure of bacterial chromosome, structure of eukaryotic chromosome, nucleosome organization, arrangement of chromatin fibers in a chromsome. Polytene chromosomes, Centromere and telomere structure. Allocating genes to chromosomes.

Molecular Genetics: Mutations; nature of mutations, spontaneous and induced mutation, conditional, lethal (temperature sensitive) mutation.

Biochemical basis of mutation. Point mutation, base substitution mutation, missense, nonsense and silent mutation. Mutation rates.

Chemical mutagens, radiation induced mutation, reverse mutations and suppressor mutations - intergenic and intragenic suppression, reversion as a means of detecting mutagens - Ames test.

Repair Mechanism: Reciprocal recombination, site specific recombination, Ecoli rec system. Holliday model of recombination.

Chromosomal Basis of Human Diseases: Extra or missing chromosome, abnormality in chromosome structure; deletion, duplication, inversion, translocation.

COURSE-V : PLANT BIOTECHNOLOGY

Objectives are:

- To study the process of induction of secondary metabolites by plant cell culture and production of chemicals.
- To study the *Agrobacterium*-mediated gene transfer technique in plants.
- To study the generation of transgenic plants and their applications in molecular farming.
- To study the preservation of seed-propagated species, pollen and vegetative propagated species.

Course outcome the student will:

- Understand the mechanism of induction of secondary metabolites by plant tissue culture.
- Understand the process of transformation of plant cells.
- Understand the importance of transgenic plants and their negative/positive impact.

Course Contents:

Protoplast Technology: Isolation, purification and culture of protoplasts, protoplast fusion and somatic hybridization, applications of somatic hybrids/ cybrids.

Secondary metabolite production: Induction of secondary metabolites by plant cell culture, technology of plant cell culture for production of chemicals, biotransformation using plant cell culture. Bioreactor systems and models for mass cultivation of plant cells.

Plant transformation techniques: Methods of gene transfer in plants, *Agrobacterium* mediated transfer- mechanism of DNA transfer.

General features of Ti and Ri plasmids, role of *vir* genes, design of expression vectors, use of promoters and reporter genes; viral vectors, direct gene transfer methods- electroporation, microinjection, particle bombardment, selection of transformants, screening and field trials.

Cell and Tissue Culture Technology: Role of hormones in growth and development of plants, tissue-specific hormones. Callus Induction, Organogenesis, Somatic embryogenesis, cell suspension culture and synthetic seeds.

Micropropagation: Propagation from pre-existing meristem, shoot apical meristem, shoot and node culture, micropropagation stages and applications.

Haploid Technology: Methods of haploid culture, Factors affecting anther and microspore cultures, applications.

Transgenic plants: Herbicide resistance, resistance against biotic stress- bacterial, viral, fungal and insect resistance, abiotic stress, improved crop productivity, improved nutritional quality, transgenic plants for floriculture, Qualitative trait loci and marker studies.

Molecular farming: Transgenic plants as production systems-production of alkaloids, steroids, colouring agents, flavoring agents, biodegradable plastics, industrial enzymes, therapeutic proteins, biopharmaceuticals, edible vaccines, plantibodies.

Germplasm preservation: Preservation of seed-propagated species, preservation of pollen, preservation of vegetatively propagated species, pre-treatment of plant and propagule, cryopreservation, cryoprotectant, warming rate and recovery, gene banks, applications.

COURSE-VI : ANIMAL BIOTECHNOLOGY

Objectives are:

- To study the methods of isolation of primary cell culture from mouse, chick embryos and human biopsis.
- To study the culture and applications of various types of animal cells including epithelial cells, tumor cells and immune cells.
- To study the methods involving in invitro fertilization and embryo transfer in humans and farm animals.
- To study the applications of transgenic animals.

Course outcome the student will:

- Understand the preparation and culture of animal cell culture.
- Understand the applications of epithelial cells, tumor cells and immune cells in studying the disease conditions and drug targets.
- Understand the importance of transgenic animals and their legal and socio-economic impact.

Course Contents:

Culture of animal cells: Advantages and limitations of tissue culture, aseptic handling, and 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.

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.

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.

***IN VITRO* fertilization and Embryo transfer:** *In vitro* fertilization in Humans, Embryo transfer in Humans, Super ovulation and embryo transfer in farm animals (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 from long-term cultured cells. Cloning efficiency, cloning for production of transgenic animals, gene targeting for cloned transgenic animals, cloning for conservation.

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

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

COURSE-VII : MOLECULAR BASIS OF EVOLUTION Objectives are:

- To study the Lamarck and Darwin concepts of natural selection.
- To study the experimental evidence for the origin of cells and evolution.
- To study the history and theories of molecular evolution.
- To study the process of evolution of organisms.

Course outcome the student will:

- Understand the evolutionary theories of Lamarck and Darwin.
- Understand the evolutionary evidence organisms.

Course Contents:

Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection.

Mendelism; spontaneity of mutations; the evolutionary synthesis. Basis for Darwin's theory; confounding observations from embryology, comparative anatomy and biochemistry. Haeckel's drawings of embryos to fit the theory of evolution.

Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.

Molecular Evolution: Concept of Neutral theory of evolution. Molecular divergence and molecular clocks, molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence

Evolutionary history: Major events in the evolutionary time scale; origins of unicellular and multicellular organisms; major groups of plants and animals. Punctuated equilibrium and phylectic gradualism, stages in primate evolution including Homo.

Geological time scale, pre biotic conditions. Dating of fossils, different methods, current controversies concerning theory of evolution.

Controversies concerning evolution of prokaryotes vs. eukaryotes, birds vs. dinosaurs, age of humans, asexual vs. sexual reproduction, cold blooded vs. warm blooded; living fossils, evolution of birds and dinosaurs, hoaxes and falsification of data (Javaman).

COURSE-VIII : BASICS OF BIOSTATISTICS

Objectives are:

- To study the sampling techniques and significance of biostatistics.
- To study the collection and representation of statistical data.
- To study the applications of various means of statistical analysis.

Course outcome the student will:

- Understand the collection and graphical representation of statistical analysis.
- Understand the sample size and hypothesis testing.
- Understand the various means of statistical analysis including t test, ANOVA, correlation and regression.

Course Contents:

Introduction to Biostatistics: Population, sample, sampling techniques, random sample.

Mean, median, mode, range, variance, coefficient of variation, frequency, standard deviation, standard error. Representation of statistical data line graph, histogram, bar diagram, pie chart, scatter diagram.

Collection of data: Relevance of sample size. Sources, methods-questionairs, records, archives, scaling-Likert and Gutman. Validation and standardization of the methods, modification and experimental design.

Probability: Rules of probability, binomial distribution, normal distribution, area under the curve, Z value, choosing sample size, hypothesis testing, Student's t test. One way ANOVA, correlation and regression.

X2 test: goodness of fit, test of independence.

Non parametric statistics, sign test, rank sum test, rank correlation.

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