MSc Biochemistry Syllabus

(Approved by the BoS and Standing Committee)

Effective from July 2015

COURSE CONTENT

		Credits	Marks
SEMESTER – I	**[Only Core Courses]***		
Course I	MFC 001: Foundation Course**	8	200
Course II	MBC 101: Biomolecules	4	100
Course III	MBC 102: Cell Biology	4	100
Course IV	MBC 103: Enzymes	4	100
Course V	MBC 104: Lab Course-1	8	100
	(Analytical and separation techniques)	----	------
		28	600
SEMESTER – II	**[Only Core Courses]***		
Course VI	MBC 101: Molecular Biology	4	100
Course VII	MBC 202: Protein and Proteomics	4	100
Course VIII	MBC 203: Metabolism-I	4	100
Course IX	MBC 204: Biochemical and Biophysical Techniques	4	100
Course X	MBC 205: Lab Course-2	8	200
	(Enzyme analysis and immobilization techniques)	----	------
		24	600
SEMESTER – III	**[Only Core Courses]***		
Course XI	MBC 301: Immunology	4	100
Course XII	MBC 302: Genetic Engineering	4	100
Course XIII	MBC 303: Metabolism-II	4	100
Course XIV	MBC 304: Clinical and Nutritional Biochemistry	4	100
Course XV	MBC 305: Dissertation-1	8	200
	(Protein isolation, purification and immunological techniques)	----	------
		24	600
SEMESTER – IV			
Discipline Centric Elective Courses* **			
Course XVI	MBC 401: Biotechnology	4	100
Course XVII	MBC 402: Bioinformatics and Biostatistics	4	100
Course XVIII	MBC 403: Microbiology	4	100
Generic Elective Course* **			
Course XIX	MBC 404: Introduction to Manuscript writing and Research presentation	4	100
Core Course*			
Course XX	MBC 405: Dissertation-2	8	200
	(Molecular biology and microbiology techniques)	----	------
		24	600

Total credits in four semesters: 100
Total marks in four semesters: 2400

Each theory paper will be taught in 50 lectures, each of one-hour duration, except the Foundation Course.

***** Core courses are compulsory and integral part of the subject.

****** The Foundation Course will be coordinated by the Dean of the Faculty. It will be covered in 100 lectures and will have its own core and elective components.

*******Students may choose any paper from any department/faculty against the elective paper subject to the availability of time slot.

SEMESTER-I

Course I
Paper Code: MFC 001

FOUNDATION COURSE

CREDITS: 8, LECTURES: 100, MAXIMUM MARKS: 200 (50 INTERNAL ASSESSMENT + 150 SEMESTER EXAM)

The objective of this course is to enable the student to refresh her/his knowledge and prepare her/him for respective postgraduate program of study in faculty of science. The course will be coordinated by the Dean of the faculty, and classes will be held along with semester I students admitted in various departments of the science faculty.

Unit I: CHEMISTRY

Essential:

- Solution: Methods of expressing the concentration (Molality, Molarity, Normality etc.). Colligative properties, Molecular mass determination using colligative properties, basics of Nanotechnology.
- Rate of reaction, order of reaction, molecularity of reaction.
- Ionic or Electrovalent bond, Covalent bond, Types of overlapping and nature of covalent bonds, Hybridization, examples of Sp^3, Sp^2 and Sp Hybridization, Co-ordination bond, Hydrogen bonding.
- Principle of Chromatography, Classification of chromatographic techniques, TLC and paper chromatography, Application of chromatography.
- Basics of Spectroscopy and applications.

Desirable:

- Laws of mass action, Reaction Quotient, Chemical equilibrium constant, Relation of Kp & Kc, pH, buffer, buffer index, buffer capacity, Arrhenius equation & Nanotechnology.
- Principles and applications of GC, HPLC, Ion exchange and Size exclusion chromatography.
- Principles of UV/VIS, IR and NMR Spectroscopic techniques and applications.
- Synthesis and applications of Nanoparticles.

Unit II: BIOCHEMISTRY

Essential:

- Biomolecules: Carbohydrates, amino acids/proteins, lipids and nucleotides; Enzymes: Characteristics and nomenclature.
- Cell Biology & Microbiology: Prokaryotes & Eukaryotes; Cell and its composition; Cell organelles and subcellular fractionation; Viruses, Viroids, Virusoids and Prions; Bacterial culture and growth curve.
- Bioenergetics and Intermediary Metabolism: ATP as energy currency; Intermediary metabolism.
- Immunology: Active, passive, Humoral and Cellular immunity; Clonal selection theory; Cells of immune system; Immunoglobulins; Haptens, Antigens and Immunogens; Monoclonal & Polyclonal antibodies.

Desirable:

- Gene transfer Mechanisms in bacteria & Gene expression: Conjugation, Transformation and Transduction; expression of eukaryotic genes in prokaryotes.
- Clinical Biochemistry: Biochemical tests; Quality assurance; Acid base disorders; Liver function test; Kidney function tests.
- Glucose Metabolism: Glycolysis and TCA cycle; oxidative phosphorylation; Aerobic & anaerobic Fermentation.
- Hybridoma technology.

Unit III: BOTANY

Essential:

- Biodiversity – Concept, levels and Conservation of biodiversity.
- Climate Change – Consequence, CO_2 fertilization, global warming, sea level rise, UV radiation.
- Ecosystem - Producers, consumers and decomposers of food chain.
- Natural Resources - Renewable and non-renewable resources of energy.
- Plant drugs and their constituents used in allopathic system of medicine.

Desirable:

- Environment - International efforts and India initiatives in biodiversity conservation, Endemism, biodiversity hotspots; bioremediation, Bioindicators, greenhouse gases (trend and role), ozone layer and ozone hole; Environmental pollution.
- Toxic and poisonous plants, Petrocrops and energy plantation.
- Plant breeding and crop improvement (wheat, cotton, *BRASSICA*).

Unit IV BIOTECHNOLOGY

Essential:

- Genetics of Inheritance - Laws of inheritance, recombination, segregation of traits, segregation ratio, interaction between traits and quantitative inheritance.
- Molecular Biology - The genetic material, RNA as genetic material, fidelity of DNA replication, transcription, translation, gene regulation. Mutation and mutagenesis, Ames test, Transposons.
- Genetic Engineering - Essentials of gene manipulation, vectors & enzymes used in recombinant technology.

Desirable:

- Applications - Stem cell research application, disease tolerant plants, insecticide and herbicide tolerant plants, increasing the shelf life of vegetables and fruits, improvement in quality (golden rice) and quantity of produce.
- Biotech and Society - Apprehensions for GM crops-effect on ecosystem, development of tolerance, loss of genetic base, loss of diversity, IPR concerns, adaptation, judicious implementation.

Unit V TOXICOLOGY

Essential:

- Introduction to Toxicology:
  - Various types of toxicity (Acute, subacute, subchronic and chronic).
  - Chemical interactions (Additive effect, potentiation, synergism and antagonism), Dose response relationship (ED50, LD50 EC50, LC50.)
  - Routes of exposure, absorption, distribution, elimination. *IN VITRO* and *IN VIVO* models in toxicological studies.
- Metabolism of xenobiotics: Common toxicants of air, water & food - metabolism & impact on human health.
- Concept and requirement of Good Laboratories Practices (GLP), GMP, GCP.

Desirable:

- Tumor Markers.
- Chemical carcinogenesis & dietary intervention.
- Enzyme inhibitors.

Course II
Paper Code: MBC 101 ***Core Course***

BIOMOLECULES

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

Objective of this course is to introduce the student the structure and function of biomolecules, and understand the chemical principles in life processes. Classification, disorders related to overproduction and underproduction of hormones are also emphasized in this paper.

Unit I: Carbohydrates

Occurrence, classification, characteristics, structure and functions of monosaccharides, disaccharides, trisaccharides and polysaccharides; Structure and conformation of sugars; Stereoisomerism and optical isomerism; Selected chemical reactions of the functional groups; Sugar derivatives; Mucopolysaccharides; Glycosaminoglycans; Proteoglycans; Glycoproteins.

Unit II: Lipids

Classification and types of lipids; Structure, nomenclature and properties of fatty acids; Glycosides; Soaps; Micelles; Structure, classification, properties and functions of phospholipids and sphingolipids; Glycolipids; Composition and biological role of lipoproteins; Structure and functions of steroids and prostaglandins; Eicosanoids; ω3 and ω6 fatty acids.

Unit III: Amino acids, nucleotides and water

Structure, nomenclature, classification, acid-base behavior and chemical reactions of amino acids; Stereoisomerism and optical properties of amino acids; Modified amino acids; Nucleotides; Water and its physicochemical properties, Ionization of water, pH scale, Henderson-Hasselbalch equation.

Unit IV: Hormones/Signaling molecules

General characteristics of hormones and other signaling molecules; Classification, functions, mechanism of action and abnormalities of the hormones of thyroid, pancreas, hypothalamus, pituitary and gonads; Hormone replacement therapy; Plant hormones with specific reference to Auxins; Pheromones: types and functions.

Course III
Paper Code: MBC 102 ***Core Course***

CELL BIOLOGY

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

Cell is the unit of life and the site where the processes of life originate and occur. This paper is aimed at to provide an insight into the organization, biochemistry and functions of the cell, and is expected to make the student understand the biological sciences and explore the reactions and processes in living organisms for the benefit of mankind.

Unit I: An overview of the cell and cell structure

Introduction to the cell: chemical composition, molecular organization, origin and evolution; Prokaryotic and eukaryotic cells; Cell theory and modern cell biology; Cell organelles: structure of endoplasmic reticulum, golgi body, endosome, lysosome, vacuole, peroxisome, ribosome, mitochondria, chloroplast, nucleus, cytoskeleton, plant cell wall; Subcellular fractionation; Marker proteins; Protoplasm, cytoplasm and cytosol; Methods to study the cell: Principles of microscopy, tissue culture and flow cytometry.

Unit II: Membrane biology

Membrane: chemical composition and its structural plan; Membrane models; Membrane as a two dimensional fluid; Factors affecting the fluidity and permeability of membrane; Phase transition; Membrane proteins: types and isolation; Movement of small molecules and ions across membrane; Movement of macromolecules across membrane; Osmosis; Diffusion; Active and passive transport; Types of ATPases; Endocytosis; Clathrin mediated endocytosis; Phagocytosis; Membrane fusion; Artificial membranes.

Unit III: Major cell functions

The cytoplasmic membrane or endomembrane system; Secretion and transport of proteins to membranes (integral membrane proteins) and various organelles; Signal hypothesis; Protein targeting to peroxisome; Major functions of various cell organelles; Packaging of eukaryotic DNA into chromosome; Nucleosome and higher levels of organization; Nuclear pore complex and its function; Trafficking across nucleus; Nucleolus and the synthesis of ribosome; Electric properties of membrane; Patch clamp and voltage clamp techniques.

Unit IV: Regulation of cell functions

Signal transduction; Receptors and ligands; Proteins and molecules involved in transduction of signal into the cell; G proteins and G protein coupled receptors; Growth factors and receptor tyrosine kinase; Second messengers; Cell cycle and its regulation; Cancer; Characteristics of tumor cells; Mechanism of transformation; Angiogenesis; Tumor suppressor genes; Cell signaling in development and differentiation; Regulatory genes in the development of *Drosophila*; Stem cell; Regeneration; Autophagy and cell death.

Course IV
Paper Code: MBC 103 ***Core Course***

ENZYMES

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

This course is meant to give student an in-depth knowledge of enzyme, their classification, catalysis and kinetics, as well as to give an account of the catalytic mechanisms and immobilized enzymes.

Unit I: Enzymes – Introduction and classification

Enzymes as biological catalysts: characteristics, nomenclature and classification; Enzyme assay and enzyme activity; Enzyme units; Coenzymes: structure and function; Factors affecting initial velocity of enzyme catalyzed reactions; Multifunctional enzymes and multienzyme complexes; Isoenzymes and their analysis; Ribozyme; Catalytic antibodies.

Unit II: Enzyme kinetics and enzyme inhibition

Kinetics of enzyme catalyzed reactions; Steady-state hypothesis and derivation of Michaelis-Menten equation; Significance of Km and Vmax and their determination using different plots; Double reciprocal plot; Enzyme inhibition: competitive, noncompetitive, and uncompetitive inhibition; Excess substrate inhibition; Enzyme kinetics in the presence of inhibitors; Determination of Ki; Enzyme catalyzed reactions involving two substrates.

Unit III: Catalytic mechanisms

Catalytic efficiency and factors associated with catalytic efficiency: proximity, orientation, distortion and strain; Catalytic mechanisms: acid-base, covalent, metal ion and electrostatic catalysis; Active site mapping of enzymes; Experimental approaches to the determination of enzyme mechanisms; Mechanism of action of lysozyme and serine proteases.

Unit IV: Regulation of enzyme activity and immobilized enzymes

Mechanisms to control the enzyme activity; Allosteric enzymes and their kinetics; Hill and Scatchard plots; Models of allosteric regulation; Enzyme immobilization: methods, kinetics and applications; Enzyme turnover and its significance; Convergent and divergent evolution of enzymes; Non-enzymatic biochemical reactions.

Course V
Paper Code: MBC 104 ***Core Course***

LAB COURSE - I
(Analytical and Separation Techniques)

CREDITS: 8, HOURS: 200, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

Exercises in the lab course are primarily aimed at providing hands-on training to the student on various analytical and separation techniques, and introduce him to the methods of studying biological molecules. Teacher supervising the lab will be explaining the principle, theory and instrumentation of the technique to be used before starting the practical exercise.

Lab Exercises

1. Qualitative analysis of carbohydrates, lipids, amino acids, and proteins from biological sample.
2. Quantitative (spectrophotometric) analysis of glucose, protein and cholesterol.
3. Chromatographic separation of sugars, fatty acids, and amino acids by paper and thin layer chromatography.
4. GC, HPLC, HPTLC (Demonstration only).
5. Isolation of polysaccharide (starch or glycogen) from the biological material.
6. Isolation of casein from milk.
7. Digestion of casein and determination of phosphate in the digest.
8. Extraction of lipid/oil from plant material and determination of its saponification value and iodine number.
9. Centrifugation technique: subcellular fractionation, and isolation of nuclei and mitochondria from the tissue.
10. Immobilization of cell: RBC/yeast.
11. Determination of pK values of amino acids.

SEMESTER-Ii

Course VI
Paper Code: MBC 201 ***Core Course***

MOLECULAR BIOLOGY

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

This course deals with a detailed insight into the structure and function of nucleic acids.

Unit I: Nucleic acids Principles of Heredity

DNA as genetic material; Levels of structures of DNA; Forms and properties of DNA; Properties of DNA in solution; COT curves; Central dogma of molecular biology.
RNA: Structure function and types of RNAs; unusual bases in RNA.
Mendelian principles: Dominance, segregation, independent assortment, and pleiotropy; Allelic frequency and its calculation.
Molecular evolution: Separation, natural selection, and evolution of proteins and nucleotide sequences; Gene duplication and exon shuffling; Deleterious genes; Eugenics; Conservation of gene frequencies; Molecular clocks; Convergent evolution.

Unit II: Replication and Transcription

Replication of DNA; Enzymes involved in replication; Mechanisms of replication; Proof reading function and fidelity of DNA replication; Modes of DNA replication in prokaryotes and eukaryotes; Role of chromatin structure in gene expression; Replication of viral RNA. Repair mechanism in prokaryotes and eukaryotes.
Transposable elements in bacteria; Mobile elements in eukaryotes.
Transcription in prokaryotes and eukaryotes; Regulatory region and transcriptional unit of gene; Inhibitors of transcription; Reverse transcription.
Post-transcriptional processing of RNA: splicing, cap addition and polyadenylation; Polynucleotide phosphorylase.

Unit III: Translation and Post-translational modifications

General features of the genetic code; Ribosome as the site of protein synthesis; Activation of amino acids; Initiation, elongation and termination of protein synthesis in prokaryotes and eukaryotes; Fidelity of protein synthesis; GTPase timer; Bioenergetics of protein synthesis; Control of translation: Role of guanine nucleotides.
Post-translational processing of the polypeptide chains; Acylation, methylation, sulfation phosphorylation and glycosylation.
Mutations: Classification and molecular basis; Ames test and other testing systems.

Unit IV: Regulation of gene expression and Epigenetics

Regulation of gene expression in prokaryotes: Negative and positive control; Concept of operon; Transcriptional termination control via mRNA alternative conformations; Regulation of gene expression in eukaryotes; Britten-Davidson model; Control by steroid hormones; Cytoplasmic regulation of gene expression.
Epigenetics: Chromatin remodeling; Histone Modifications; Histone variants; Silencing mechanisms; RNA-based silencing; DNA Methylation/imprinting; Epigenetic regulation of transcription. Role of epigenetic mechanisms in normal development and oncogenesis; Molecular techniques and animal models used in the studies of epigenetic phenomena.

Course VII
Paper Code MBC 202 ***Core Course***

PROTEIN AND PROTEOMICS

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

The main aim of this course is to understand proteins, their structure, conformation and dynamics, protein folding, protein ligand interactions, and mechanisms. The paper emphasizes on various aspects of proteomics, understanding and exploring applications of mass spectrometry in protein structure determination.

Unit I: Primary structure

An overview of protein structure; Globular and fibrous proteins; Hierarchy of protein structure; Determination of N and C-terminal residues; Dihedral angles; Ramachandran plot; Determination of amino acid composition of protein and determination of sulfhydryl groups; Location of disulfide bonds; Fingerprinting; Chemical synthesis of peptides.

Unit II: Secondary and tertiary structure

Secondary structure of proteins: alpha helix and beta structure; Dinucleotide fold; Collagen helix and other types of helical structures; Supersecondary structures; Amino acid sequence and three dimensional structure; Domains; Forces stabilizing the secondary and tertiary structure; Protein purification; Criteria of purity, and fold purification.

Unit III: Sequencing, protein folding and denaturation

Protein sequencing; Sequenators; Hydropathy plot; Quaternary structure of proteins; Structure and function of hemoglobin and comparison with myoglobin; Characteristics of molten globule state; Proteins involved in folding; *in vivo* folding; Models of protein folding; Chaperones; Protein conformation and misfold diseases.

Unit IV: Proteomics

Overview, tools and applications; Two-dimensional polyacrylamide gel electrophoresis; Protein spot detection; Mass spectrometry: matrix assisted laser desorption ionization MS, electrospray ionization MS, and tandem MS for protein identification; Identification of protein-protein interactions; Protein complexes; Prediction of tertiary structure (introduction).

Course VIII
Paper Code MBC 203 ***Core Course***

METABOLISM - I

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM

This course deals with the introduction to the laws of thermodynamics and their significance in biological systems, the concept of metabolism, characteristics of metabolic pathways and strategies used to study these pathways. This is followed by a detailed overview of various pathways involved in carbohydrate metabolism with their significance and regulation. The course also focuses on some important plant-specific metabolic pathways with relevant details.

Unit I: Bioenergetics and Introduction to Metabolism

Bioenergetics: Laws of thermodynamics; Concept of free energy, and standard free energy change; Determination of free energy change for a reaction; Equilibrium constant and standard free energy change; Biological oxidation-reduction reactions; Standard reduction potential and its relationship with free energy change.
Metabolic pathways: Characteristics of metabolic pathways; Strategies used to study metabolic pathways.
High energy compounds: ATP as universal energy currency in biological systems; Processes that generate and utilize ATP in the cell; Other high-energy compounds; Role of NADH and NADPH in metabolism.

Unit II: Carbohydrate Metabolism

Digestion and absorption of carbohydrates; Glycolysis; Entry of other monosaccharaides in glycolytic pathway; Gluconeogenesis; Citric acid cycle; Pentose phosphate pathway; Glucuronate pathway; Biosynthesis of lactose; Biosynthesis of oligosaccharides and glycoproteins; Glycogen metabolism and its regulation; Glycogen storage diseases and other genetic defects in carbohydrate metabolism; Regulation of carbohydrate metabolism; Metabolic adaptation in starvation and diabetes mellitus.

Unit III: Mitochondrial ATP Synthesis

Mitochondrial electron transport chain: Properties of inner mitochondrial membrane; Electron carriers and their organization; Sequence of respiratory complexes; Protein and no-protein components of respiratory complexes; Transport of equivalents of NADH produced in cytoplasm; $FADH_2$ oxidation.
Oxidative phosphorylation: Sites of phosphorylation; P/O ratio; ATP synthase and mechanism of ATP synthesis; Inhibitors and uncouplers; Energetics and regulation of oxidative phosphorylation.

Unit IV: Plant-Specific Metabolic Pathways

General pathways: Glyoxylate pathway; Photosynthesis and carbon fixation; Cyclic and noncyclic electron transport; C3, C4, and CAM pathways; Photorespiration; Biosynthesis of Sucrose, starch and cellulose; Role of vacuole in plant metabolism.
Plant secondary metabolism: Significance of secondary metabolites; Major classes of secondary metabolites and their properties; Common metabolic precursors; Outline of biosynthesis pathways of Alkaloids, Phenolics, Glycosides, and Terpenoids.

Course IX
Paper Code MBC 204 ***Core Course***

BIOCHEMICAL AND BIOPHYSICAL TECHNIQUES

CREDITS: 4. LECTURES: 50. MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

This course has been designed to introduce the student to various classical and modern techniques used in biochemical research. The course encompasses the principles, significance, applications, and limitations of these techniques. The basic instrumentation is also included.

Unit I: Spectroscopy

Principle, instrumentation, and applications of Colorimetry, UV-Visible Spectroscopy, Fluorescent and Emission Spectroscopy, IR Spectroscopy, Atomic Absorption Spectrometry, NMR, ESR, CD, ORD, Raman, Atomic force microscopy, and X-Ray Crystallography; Difference spectra.

Unit II: Chromatography

Partitioning and Counter Current distribution; Principle, instrumentation, and applications of Paper chromatography, Thin layer chromatography (TLC), Gel permeation (size exclusion) chromatography, Ion exchange chromatography, Affinity chromatography, Immobilized metal ion affinity chromatography (IMAC), Hydrophobic interaction chromatography, Gas chromatography, HPLC, HPTLC, RP-HPLC, and FPLC.

Unit III: Centrifugation and Electrophoresis

RCF; Types of rotors; Principle, instrumentation and applications of Centrifugation, Ultracentrifugation, CsCl and sucrose density gradient Ultracentrifugation; Principle, instrumentation and applications of Native PAGE, SDS-PAGE, Agarose, Starch, and Cellulose acetate electrophoresis; Electrophoresis in determining M_r and conformation; Moving boundary & zonal electrophoresis; Pulse field gel electrophoresis, Blotting techniques; Zymography.

Unit IV: Radioisotopic / Tracer Techniques

Radioisotopes; Units of radioactivity; Detection and measurement of radioactivity by gas ionization and scintillation counting; GM Counter; Gamma counter; Autoradiography; Fluorography; Phosphor imaging; Isotope dilution method-pulse chase; RIA; Alternative to radioactivity: Luxometry and chemiluminescence.

Course X
Paper Code MBC 205 ***Core Course***

LAB COURSE - II
(Enzyme Analysis and Immobilization Techniques)

CREDITS: 8, HOURS: 200, MAXIMUM MARKS: 200 (50 INTERNAL ASSESSMENT + 150 SEMESTER EXAM)

This course is aimed at to make the student understand the procedures involved in experiments on enzymes, train them on methods of preparation of buffer including Henderson-Hasselbalch method, pH & pK determination, and methods for the isolation of enzymes, measuring their activity, kinetics, assays, immobilization, and studies on denaturation. The course also includes exercises on the Western blotting, SDS-PAGE, and UPLC-MS. Faculty supervising the course will be explaining the principle, theory and instrumentation of the technique to be used before starting the practical exercise.

Lab Exercises

1. Preparation of buffers and determination of pH.
2. Isolation and assay of an enzyme and determination of its kinetic properties.
3. Immobilization of enzyme and measurement of its activity.
4. Effect of pH, time and temperature on enzyme activity.
5. Analysis of lactate dehydrogenase isoenzymes.
6. Experiments on protein denaturation.
7. Assay of clinically important enzymes.
8. Western blotting (Demonstration only).
9. UPLC MS (Demonstration only).

SEMESTER-IIi

Course XI
Paper Code MBC 301 ***Core Course***

IMMUNOLOGY

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

The course on immunology is intended to make the student aware of the types of immunity, and biochemical mechanisms involved in immune responses and immune-mediated diseases. An introduction to immunotechnology, and other emerging areas in this field, is also included.

Unit I: Types of immunity

Innate Immunity and Adaptive Immunity; Cells and organs of immunity: Primary and secondary lymphoid organs; T cells, B cells, macrophages and effecter cells; Macrophage plasticity; Humoral and cellular immunity; Antigens and immunogens; Immunoglobulins: types and structure; CDRs; Immunoglobulin fold; Isotypes, allotypes and idiotypes; Valency, affinity and avidity; Primary and secondary immune response; Immunological memory; Clonal selection theory.

Unit II: Immune responses: T & B cell interaction

The immunoglobulin genes: organization and assembly; Generation of immunological diversity; Major histocompatibility complex (MHC): structure and organization of MHC class I and class II molecules; Antigen processing and presentation; T-cell receptor: αβ and γδ TCR; T cell maturation, activation and differentiation; Types of B cells; B cell generation, activation and differentiation; T-dependent and T-independent antigens.

Unit III: Immune effector mechanisms

B cell mediated effector responses; Cell mediated effector responses; Cytokines: properties and functions of lymphokines, monokines, interleukins and chemokines; Complement and mechanism of complement fixation; Hypersensitivity; Types of hypersensitivity reactions.

Unit IV: Immune-mediated diseases & Immunotechnology

Tolerance and autoimmunity; Immunoregulation; Immune response to infectious diseases; Viral, bacterial and protozoal infections; H1N1; Cancer immunotherapy; Mucosal immunity; Adjuvants; Immunotherapy; Plant defense mechanisms; Immunoprecipitation; Agglutination; Immunoelectrophoresis; Immunofluorescence; Cytotoxicity assay; ELISPOT; ELISA; Western blotting; Flow cytometry; Immunization protocol.

Course XII
Paper Code MBC 302 ***Core Course***

GENETIC ENGINEERING

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

This course will give a professional approach to the field of genetic engineering. After the delivery of the course, student will have an understanding of the concepts and major issues concerning gene cloning, analysis of genes and genome by DNA sequence analysis, and critical description of existing methods in gene technology.

Unit I: Gene cloning and construction of gene library

Gene cloning strategies; Isolation and purification of nucleic acid and its quantification and analysis; Molecular tools and their applications; Restriction endonucleases; DNA modification enzymes; Site directed mutagenesis; Cloning vectors; Ligation of DNA fragments: Linkers, adapters and homopolymeric tailing; Synthesis of cDNA; Construction of genomic library; mRNA enrichment; Reverse transcription and library construction; DNA Sequencing.

Unit II: Expression systems

Expression vectors; Choice of expression system; Expression in bacterial, yeast, insect and mammalian cells; Baculovirus expression systems; Expression of heterologous genes; Factors affecting the expression of cloned genes; Codon bias; Vector engineering and codon optimization; Host engineering.

Unit III: Recombinant proteins and transgenics

Processing of recombinant proteins: purification and refolding; Characterization of recombinant proteins; Stabilization of recombinant proteins; Transgenic and gene knockout technologies; Transgenic methodology; Transgenic animals and plants; Targeted gene replacement; Chromosome engineering; Value addition through genetic engineering; Protein engineering.

Unit IV: PCR and DNA fingerprinting

Polymerase chain reaction: principles, process, design and optimization; Taq DNA polymerase; Types of PCR: allele specific, inverse, asymmetric, and real-time PCR; Application of PCR in diagnostics, forensic science, gene manipulation expression studies and evolutionary biology; Ligase chain reaction; SNP and application in molecular diagnostics; DNA fingerprinting: applications and prospects; restriction fragment length polymorphism (RFLP) and its uses; FISH; Prenatal diagnosis.

Course XIII
Paper Code MBC 303 ***Core Course***

METABOLISM - II

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

The paper is in continuation to the paper on metabolism in the previous semester where the metabolism of carbohydrates was discussed with significant detail. The paper gives an idea to the student about how biomolecules other than carbohydrates are metabolized. Lipids, amino acids and nucleotides have been individually addressed. The last unit deals with some unique pathways identified in prokaryotes only.

Unit I: Lipid Metabolism

Major dietary lipids; Digestion and absorption of dietary lipids; Pathways for the transport of endogenous and exogenous lipids; Major serum lipoproteins and their metabolism; Main and alternative pathways of fatty acid oxidation; Oxidation of odd carbon number and unsaturated fatty acids; Significance and metabolism of ketone bodies; Biosynthesis of saturated and unsaturated fatty acids; Metabolism of triacylglycerols, glycerolipids, sphingolipids and cholesterol; Role of leptin in the regulation of lipid metabolism.

Unit II: Amino Acid and Porphyrin Metabolism

Amino acid metabolism: Digestion of dietary proteins; Absorption of amino acids; General reactions in the degradation of amino acids; Deamination and transamination reactions; Urea cycle; Glucogenic and ketogenic amino acids; Fate of the carbon skeleton of individual amino acids; Essential and nonessential amino acids; Biosynthesis of individual amino acids; Inborn errors of amino acid metabolism; Amino acids as biosynthetic precursors.
Porphyrin metabolism: Biosynthesis and degradation of Heme; Genetic defects in heme metabolism.

Unit III: Nucleotide and Xenobiotic Metabolism

Nucleotide metabolism: Degradation of nucleic acids: deoxyribonucleases and ribonucleases; Biosynthesis and degradation of purine and pyrimidine nucleotides; Regulation of purine and pyrimidine nucleotide metabolism; Formation of NDPs and NTPs; Biosynthesis of deoxy-ribonucleotides and its regulation; Inborn errors of nucleotide metabolism; Nucleotide coenzymes.
Xenobiotic metabolism: Significance; Phases of xenobiotic metabolism; Types of reactions involved.

Unit IV: Unique Metabolic Pathways of Prokaryotes

Nitrogen fixation and properties of nitrogenase; Entner-Doudoroff pathway; Heterolactic, propionic, butyric and mixed acid fermentations; Anaerobic respiration; Methanogenesis and reverse methanogenesis; Chemoautotrophic fixation of carbon dioxide via Reductive acetyl-CoA pathway, Reductive TCA cycle, 3-Hydroxypropionate cycle and 4-Hydroxy-butyrate cycle; Anoxygenic photosynthesis; Light-driven non-photosynthetic photophosphorylation.

Course XIV
Paper Code MBC 304 ***Core Course***

CLINICAL AND NUTRITIONAL BIOCHEMISTRY

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

The clinical biochemistry section emphasizes on the concepts of quality assurance in chemical pathology/clinical biochemistry and gives an insight into the understanding of organ functions in health and disease. Nutritional Biochemistry aims at understanding the food groups, formulation of balanced diets, vitamin types, human nutrition, and the disorders that arise due to nutritional imbalances and its impact on overall health, and gives an introduction to nutrigenomics.

PART-A: CLINICAL BIOCHEMISTRY

Unit I: Clinical biochemistry and quality assurance

Clinical chemistry/biochemistry: concept, definition and scope; Biological samples: types, collection, processing, stability and storage; Phlebotomy tubes; Serum and serum separator devices; Chemical composition of biological fluids: blood, urine and cerebrospinal fluid; Reference range; Quality assurance; Accuracy and precision; Factors influencing the accuracy of results; Levy-Jennings's chart; Reliability of laboratory methods; Interferents; Responsibilities of a clinical biochemist.

Unit II: Biochemical tests in clinical practice

Biochemical tests in clinical practice: uses of a chemical/biochemical analysis; Criteria for selecting a method for biochemical analysis; Enzymes as diagnostic tool; Advantages and disadvantages of enzyme assays; Isoenzymes and their diagnostic importance; Methods for the detection of isoenzymes; Organ function tests: clinical presentation and diagnosis of the diseases of the liver and kidney; Bilirubin metabolism and hyperbilirubinaemia; Acid base disorders.

PART-B: NUTRITIONAL BIOCHEMISTRY

Unit III: Nutritional requirements

Basic concepts, scope and methodology; Principal food components; Vitamins: structure and function; Food nutrients: recommended allowances and their modifications under stress conditions; Deficiency and excess of principal nutritional components; Formula diets and crash diets; Formulation of balanced diets; Dietary standards: EAR, RDA, ADI, DRV, DRI, TUL; Water as an essential nutrient; Food preservatives; Additives and anti-nutrients; Toxic effects of food: sources, active agents and effects.

Unit IV: Nutrition in health and diseases

Protein energy malnutrition; Energy balance and requirements: basal metabolic rate (BMR); Factors affecting BMR and its measurement; Resting metabolic rate; Specific dynamic action of food; Dietary fat and heart disease and cancer; Atherosclerosis: risk factors and protective measures; Nutritional management of diabetes and obesity; Weight management; Anthropometric measurements; Nutrition and infection; Basics of nutrigenomics.

Course XV
Paper Code MBC 305 ***Core Course***

DISSERTAION - I
(Protein Isolation / Purification and Immunological Techniques)

CREDITS: 8, HOURS: 200, MAXIMUM MARKS: 200 (50 INTERNAL ASSESSMENT + 150 SEMESTER EXAM)

This course has been designed to provide hands-on experience on the tools and techniques used in protein chemistry and immunology. The experiments have been designed in such a way that the student will have the opportunity to isolate a specific protein from a natural source, purify it and determine its molecular weight. The protein will then be administered to animal to raise antibody, which will be isolated and used to demonstrate the antigen-antibody reaction. Besides, students will get an opportunity to learn isoelectric focusing and two-dimensional electrophoresis.

Lab Exercises

1. Isolation of protein from its source.
2. Salt fractionation for partial purification.
3. Dialysis.
4. Spectroscopic analysis of protein and determination of absorption spectrum and quantitative estimation.
5. Gel filtration, and Ion-exchange chromatography for further purification.
6. Polyacrylamide gel electrophoresis of the protein in the absence or presence of SDS to check purity of the preparation.
7. Determination of molecular weight by gel filtration.
8. Determination of molecular weight by SDS-PAGE.
9. Immunization of experimental animals with the purified protein.
10. Detection of antibodies in antiserum by Double immunodiffusion.
11. Isolation of IgG from the antiserum.
12. Isoelectric focusing and 2D electrophoresis (Demonstration only).

SEMESTER-IV

Course XVI
Paper Code MBC 401 ***Discipline Centric Elective Course***

BIOTECHNOLOGY

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

Understanding the biochemical processes in living organisms provide an opportunity to use these reactions and processes for the benefit of mankind. This course provides an understanding of how biochemical processes find application and improved our life. The course introduces the concept and application of plant tissue culture, transgenic technology, fermentation technology, genome analysis, gene therapy, environmental biotechnology, nanotechnology and its applications in medicine and developing nano-biosensors.

Unit I: Plant tissue culture and microbial biotechnology

Plant tissue culture: concept, methods and applications; Somaclonal variation; vector independent transformation; transgenic technology; transformation vectors; Plastome engineering; Bioreactors; Fermenting microorganisms; Batch and continuous culture techniques; Application of fermentation biotechnology; Production of penicillin; Single cell proteins; Value addition through genetic engineering; Synthetic seeds.

Unit II: Applications of gene technology

Sequencing genome; EST sequencing and sequence skimming; Genome mapping; Genetic polymorphism; Fingerprinting and fluorescent *in situ* hybridization; Determination of function of genes; Computer analysis of gene function; Assigning gene function by experimental analysis; Gene therapy: vector engineering strategies of gene delivery; Gene replacement/augmentation; Gene correction; Synthesis of DNA chips; DNA microarray.

Unit III: Environmental biotechnology

Definition and applications; Environmental monitoring; Bioindicators; Biopesticides; Biocontrol; Food chains and biomagnification; Biological mining; Biofuel; Landfills and vermin composting; Biofertilizers; Production of technology for major biofertilizers; Environment and transgenics; Ethical, social and biosafety aspects of biotechnology; Biological containment.

Unit IV: Nanotechnology

Basics of nanotechnology and its applications in biosciences; Biosystems at the nanoscale; Interaction of nanoparticles with biomolecules; Dendrimers; Quantum dots; Nanotubes; Nanoshells; Biocompatible matrices; Interaction of biological and synthetic material; Biomaterial; Nanofabrication methods and cell behavior; High throughput screening; Nanomedicine; Nanobiosensors.

Course XVII
Paper Code MBC 402 ***Discipline Centric Elective Course***

BIOINFORMATICS AND BIOSTATISTICS

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

Part-A provides an insight into the fundamentals of statistics and its application in biochemistry. Part-B of this course is meant to familiarize the student with the use of computer software in understanding life processes and to retrieve information, and use of tools for data analysis.

PART-A: BIOINFORMATICS

Unit I: Concepts of Bioinformatics

Bioinformatics: introduction and future prospects; Applications in genomics and proteomics; Public databases; Gene bank; Database searches: sequence retrieval systems; Similarity searching: BLAST, FASTA; Multiple sequence alignment: CLUSTALW; Detecting functional sites in DNA; Motif and domain prediction and analysis; Identification of open reading frames (ORF); Gene annotation technology.

Unit II: Applications of Bioinformatics

Computational methods for sequence analysis: Dot blot and dynamic programming methods; Phylogenetic analysis (UPGMA); Virtual and electronic cell; Internet tools for DNA sequence translation; Restriction enzyme mapping; Prediction of secondary structure of proteins; Application tools: primer designing, molecular mapping and computer aided drug designing; QSAR; *In silico* methods for identification of vaccine/drug target.

PART-B: BIOSTATISTICS

Unit III: Fundamentals of statistics

Arithmetic mean, median, mode: theory and simple numerical problem; Measures of variation: standard deviation, variance, coefficient of variation; Correlation, types and methods: simple, multiple, linear and nonlinear correlation, spearman's correlation, rank correlation; Regression: linear and curvilinear regression (for two variable X and Y only), Regression lines by least square method; regression equations of X on Y and Y on X only; Sample size; Power of study.

Unit IV: Tests of significance

Null hypothesis; Standard error; Level of significance; Degrees of freedom; Significance of mean for large samples; Significance in means for small samples (students t-test); Significance in ratio of two samples; F test (for difference between variance of two samples); *Chi* square test; Analysis of variance test (ANOVA) for one and two way classification; Signed rank test; Dunnet's test; Applications of various online tools: SPSS, Minitab, XLSTAT etc.

Course XVIII
Paper Code MBC 403 ***Discipline Centric Elective Course***

MICROBIOLOGY

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

The objective of this paper is to familiarize the student with concepts in microbiology.

Unit I: Prokaryotes

Bacteria: General features and organization of bacterial cell; Staining procedures; Criteria used in classification; Bacterial taxonomy; Phenetic and phylogenetic classification; Numerical taxonomy; General characteristics of major groups of bacteria.
Bacterial Growth and Nutrition: General nutritional requirements; Culture media; Types of bacterial cultures; Measurement of bacterial growth; Control of microorganism by physical and chemical methods.
Gene transfer in bacteria: Conjugation, Transformation and Transduction.
Archaebacteria: Archaea as a separate lineage; Differences from eubacteria.

Unit II: Eukaryotic Microorganisms

Algae: General characteristics; Classification and salient features of major divisions; Ecological significance and symbiotic relationships with other organisms.
Fungi: Properties and ecological role; Unicellular and multicellular forms; Mode of nutrition; modes of reproduction; Criteria used in classification and major fungal divisions; Symbiotic relationships; Common fungal diseases of humans.
Protozoa: Properties and classification; Characteristics of members of different phyla; Common human diseases caused by protozoa.

Unit III: Acellular Infectious Agents

Viruses: General characteristics of virions; Classification; Stages in viral replication; Replication of DNA and RNA viruses; Isolation, cultivation and assay methods; One-step growth curve of bacteriophages; Lysogeny and lytic cycle; Satellite and defective viruses; Viral interference; Common viral infections.
Virusoids: Properties; Types; Mode of replication.
Viroids: Characteristics; Classification; Mode of replication; Diseases caused in plants.
Prions: Characteristics; Prion diseases; Hypotheses regarding nature and pathogenesis of prions.

Unit IV: Microorganisms and Diseases

General concepts: Normal human microbiota; Opportunistic microorganisms; Koch's postulates; River's postulates; Classification of diseases; Modes of transmission of diseases; Stages in progress of a disease.
Mechanisms of pathogenicity: Portal of entry; Evasion of host defense; Host cell damage; Plasmids and pathogenicity; Cytopathic effects of viruses.
Chemotherapeutic agents: Selective toxicity and therapeutic index; Antimicrobial agents; Mechanism of action of important antibacterial, antifungal, antiprotozoal and antiviral agents.
Drug resistance: Causes of emergence; Mechanisms of development of drug resistance; Role of plasmids.

Course XIX
Paper Code MBC 404 ***Generic Elective Course***

INTRODUCTION TO MANUSCRIPT WRITING AND RESEARCH PRESENTATION

CREDITS: 4, LECTURES: 50, MAXIMUM MARKS: 100 (25 INTERNAL ASSESSMENT + 75 SEMESTER EXAM)

This course is aimed to provide a platform to the post graduate students to develop skills in manuscript writing and thereby developing better communication skills.

Unit I: Research Paper forms

Research paper forms: communication and exploration; Resources: online and print; Review of latest literature (peer reviewed); Concept of a Modern academic library; Library cataloguing, JSTOR, library of congress catalogue; Understanding Plagiarism: definition, unintentional plagiarism and consequences; Collaborative work; Copyright infringement; Additional published sources: reviews, abstracts, pamphlets, reports, books, journal and magazine articles; Unpublished sources: monographs, microform editions, CD-ROMs or DVD- ROMs.

Unit II: Noting and Drafting

Notes and Drafts; Sources: primary, secondary and tertiary; Format of the research paper; Journal type and style; Recording essential publication information (books, journal articles, internet source); Topic selection: working hypothesis, focus appropriation; Authorship concerns; Title subtitles and Keywords; Writing of abstract, introduction, conclusion and acknowledgement; Presenting evidence in tables and figures.

Unit III: Web Usage & Specific Formats

Web usage: Advantages and disadvantages; Risks involved in use of computers; Data backup; Informally published electronic sources: websites, weblog entries, electronic mailing lists; URL: .ac.in, .edu, .com, .gov, www.loc.gov; Wikipedia; DOI numbers; General format requirements: title page for class paper, dissertation, table of contents, list of tables and list of illustrations; Specific Institute/University formats for MA/MSc dissertations and MPhil/PhD thesis.

Unit IV: Mechanics of writing

Spelling, punctuation, paraphrasing, quotations, abbreviations (general principles); Footnotes versus endnotes; Symbols, names, numbers, and units of measure; Correct word usage; Revising sentences; Bibliography; Citation types, style, appendix and glossary; Acceptance, revision, and rejection; Learning from your returned manuscript; Presenting research in alternative forums: oral, poster and conference presentations.

Course XX
Paper Code MBC 405 ***Core Course***

DISSERTATION - II
(Microbiology and Molecular Biology Techniques)

CREDITS: 8, HOURS: 200, MAXIMUM MARKS: 200 (50 INTERNAL ASSESSMENT + 150 SEMESTER EXAM)

This course has been designed to provide hands-on experience on various tools and techniques in microbiology and molecular biology. The course will introduce the student the sterilization techniques, media preparation and isolation of pure culture and, at the same time, use culture to demonstrate the techniques used in molecular biology including the nucleic acid isolation, amplification and blotting techniques. Experiments have been designed to transform the bacteria and express foreign proteins in it. Besides, student will get an opportunity to learn the animal cell culture techniques.

Lab Exercises

1. Sterilization techniques.
2. Preparation of culture media.
3. Bacterial culture: establishing a pure culture; identification of bacteria; staining techniques; antibiotic sensitivity of bacteria.
4. Isolation of plasmid DNA, and its digestion by restriction endonuclease and separation of restriction fragments by agarose gel electrophoresis.
5. Isolation of RNA and separation on agarose gel.
6. Quantitative estimation of DNA and RNA.
7. DNA/RNA blotting techniques.
8. Polymerase chain reaction.
9. Green fluorescence protein (GFP) and bacterial transformation experiments.
10. Demonstration of radioactive counters and its principles; safety aspects.
11. Animal tissue culture (demonstration only).

Suggested Readings

Biomolecules

1. Principles of Biochemistry, A.L. Lehninger, D.L. Nelson and M.M. Cox (2008), 5th ed.. W.H. Freeman & Co.
2. Study Guide to Organic Chemistry, R.T. Morrison and R.N. Boyd (2002), 6th ed.. Prentice Hall of India.
3. Hormones: From Molecules to Disease, editors: E.E. Baulieu and P.A. Kelly (1990). Chapman and Hall, New York and London Hermann Publishers in Arts and Science.
4. Human Physiology (1990), The Mechanisms of Body Function, A.J. Vander, J.H. Sherman and D.S. Luciano, 5th ed.. Mc Graw Hill, New York.
5. Endocrinology, Mac E. Hadley (2000), 5th Ed., Prentice Hall International Inc.

Cell Biology

1. Molecular Biology of the Cell, Bruce Alberts, Alexander Johnson, Julias Levis, Martin Raff, Keith Roberts and Peter Walter (2008), 6th ed.. Garland Science, Taylor & Francis Group.
2. The Cell: A Molecular Approach, Geoffrey M. Cooper (2007), 4th ed., ASM Press.
3. The World of the Cell, W.M. Becker, L.J. Kleinsmith, J.Hardin (2006), Pearson Education.
4. Molecular Cell Biology, A. Berk , S.L. Zipursky, P. Matsudaira, D. Baltimore, J. Darnell, (2004), 5th ed.. W.H. Freeman & Co.
5. Molecular Cell Biology, H.F. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott (2007), 6th ed., W.H. Freeman & Co.

Enzymes

1. Comprehensive Enzyme Kinetics, V. Leskovac (2003), Kluwer Academic Publisher, N.Y.
2. Enzyme Assays, R. Eisenthal and M.J. Danson (2002), Oxford University Press.
3. Enzymes Biochemistry, Biotechnology and Clinical Chemistry, T. Palmer (2001), Ellis Harwood Publishing Ltd., New York.
4. Fundamentals of Enzymology: The Cell Molecular Biology of Catalytic Proteins, N.C. Price and L. Stevens (2000). Oxford University Press, Oxford.
5. Enzymes, M. Dixon and E.C. Webb (1979), Longman, London.

Molecular Biology

1. Genes IX, B. Lewin (2008). Oxford University Press, New York.
2. Biochemistry and Molecular Biology, W.H. Eliott (2005), 3rd ed., Elsevier Academic Press.
3. Molecular Biology: Understanding the Genetic Revolution, D. Clark (2005). Oxford University Press.
4. Gene Transcription Mechanisms and Control, R.J. White (2001), Blackwell science.
5. Regulation of Gene Expression in *E. coli*, E.C.C. Lin, A.S. Lynch (1996). Chapman & Hall.

Protein and Proteomics

1. Principles of Biochemistry, D.L. Nelson & M.M. Cox (2008), 5th ed., W.H. Freeman & Co.
2. Biochemistry, Jeremy M. Berg, John L. Tymockzo, Lubert Stryer (2007), 6th ed., W.H. Freeman and Co.,NY.
3. Protein Structure, Stability and Interactions, John M. Shriver (2009), Humana Press.
4. Introduction to Protein Structure, Carl Branden and John Tooze (1999), 2nd ed.. Garland Publishing Inc.
5. Proteins: Structure and Molecular Properties, T.E. Creighton (1993), 2nd ed.. W.H. Freeman & Co.

Metabolism - I

1. Principles of Biochemistry, D.L. Nelson and M.M. Cox (2008), 5th ed., W.H. Freeman & Co.
2. Biochemistry, D. Voet and J.G. Voet (2004), 3rd ed.. John Wiley and Sons Inc.
3. Biochemistry, J.M. Berg, J.L. Tymoczko and L. Stryer (2007), 7th ed., W.H. Freeman & Co.
4. Essentials of Glycobiology, E. Etzler et.al. (2009), Cold Spring Harbor Laboratory Press.
5. Plant Physiology, L. Taiz and E. Zeiger (2006), 4th ed., Sinauer Associates Inc.

Biochemical and Biophysical Techniques

1. Principles of Physical Biochemistry, Kensal E. Van Holde, W.C. Johsnon, P. Shing O (2006), 2nd ed., Pearson Education International.
2. Physical Biochemistry: Principles and Application, David Sheehan (2000), John Wiley and Sons.
3. Principles and Techniques of Biochemistry and Molecular Biology, K. Wilson and J. Walker (2010) 7th ed., Cambridge University Press.
4. Physical Biochemistry, David Freifelder (1982), 2nd ed., W.H. Freeman & Co.
5. Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry, Irwin H. Segel (1976), 2nd Ed., John Wiley & Sons.

Immunology

1. Essential Immunology by P.J. Delves, S.J.Martin, D.R. Burton, I.M. Roitt. 12th ed., Wiley Publishing House.
2. Immunology, W.E. Paul (2008), 5th ed., Wolters Kluwer.
3. The Elements of Immunology, Fahim H. Khan (2009), Pearson Education.
4. Immunology, J. Kuby (2007), 6th ed.. W.H. Freeman and Co., New York.
5. Essentials of Clinical Immunology, H. Chape, M. Haeney, S. Misbah, N. Snowder (2006), 5th ed., Blackwell Publishing Ltd.

Genetic Engineering

1. From Genes to Genomes: Concepts and Applications of DNA Technology, Jeremy W. Dale and Malcolm Von Schantz (2003), John Wiley & Sons Ltd.
2. Gene Cloning: Mechanics of DNA Manipulation, D.M. Glover (1986), 2nd ed.. Chapman & Hall.
3. Genetic Engineering, R. Williamson (1981-89), volumes 1-7, Academic Press London.
4. ICRF Handbook of Genome Analysis, Nigel K. Spurr, Bryan D. Young, Stephen P. Bryant (1998), volume 1 and 2, Blackwell Science.
5. Genomes 3, T.A. Brown (2007), volume 3, Garland Science.

Metabolism - II

1. Biochemistry by D.E .Metzler, 2nd ed. (2003). Academic Press, USA.
2. Biochemistry, D. Voet and J.G. Voet (2004), 3rd ed.. John Wiley and Sons Inc.
3. Biochemistry, J.M. Berg, J.L. Tymoczko and L. Stryer (2007), 5th ed., W.H. Freeman & Co.
4. Bacterial Metabolism, Gottschalk, Gerhard (1986), 2nd ed., Springer Series in Microbiology.
5. Microbiology, Bernard D. Davis, Renato Dulbecco, Herman N. Eisen, and Harold S. Ginsberg (1990) 4th ed., Illustrated. Philadelphia, J.B. Lippincott.

Clinical and Nutritional Biochemistry

1. Good Clinical, Laboratory and Manufacturing Practices, P.A. Carson and N. Dent (2009), RSC (The Royal Society of Chemistry) Publishing.
2. Clinical Biochemistry, Geoffrey Beckett, Simon Walker, Peter Rae, Peter Ashby (2006), 7th ed., Blackwell Publication.
3. Lecture Notes Clinical Biochemistry, Geoffrey Becket, Simon Walker, Peter Race, Peter Ash (2006), 7th ed.. Blackwell Publishing.
4. Tietz Textbook of Clinical Biochemistry, Carl A. Burtis and Edward R. Ashwood (1998), 3rd ed.. Harcourt Brace & company Asia PTE LTD. W.B. Sauners Company.
5. Krause' Food Nutrition and Diet Therapy, L.K. Mahan, S.E. Stumph (2004), 11th ed., Saunders Publications.
6. Nutrition Science and Application, Lori A. Smolin, Mary A. Grosvenor (2000), 3rd ed., John Wiley & Sons.
7. Human Nutrition and Dietetics, J.S. Garrow and W.P.T. James (1993), 9th ed., Churchill Livingstone Publications.
8. Harper's Illustrated Biochemistry (LANGE Basic Science), Murray, R.K., Granner, D.K., Mayes, P.A., Rodwell, V.W. (2003), McGraw-Hill Medical Publication.

Biotechnology and Nanotechnology

1. Biotechnology, Clark (2009), Academic Press.
2. Biotechnology Theory and Techniques, Jack G. Chirijian (1995), Jones and Bartlett Publishers, Boston, London.
3. Enzyme Biotechnology, M. Prakash (2007). Discovery Publishing House.
4. Environmental Biotechnology, Alan Scragg (2005), Oxford.
5. Introduction to Nanoscience, Gabor L. Hornyak (2008), CRC.
6. Bionanotechnology, Reisner (2009), CRC Press.
7. Nanotechnology in Biology and Medicine. Tuan Vo Dinh (2007), CRC Press.

Microbiology

1. Prescott, Harley and Klein's Microbiology, J.M. Willey, L.M. Sherwood and C.J. Woolverdon (2008), 7th ed., McGraw Hill Publishers.
2. Microbiology, Bernard D. Davis, Renato Dulbecco, Herman N. Eisen, and Harold S. Ginsberg (1990) 4th ed., Illustrated. Philadelphia, J.B. Lippincott.
3. Microbiology: Principles &Explorations, J.G. Black (2002), 5th ed.. John Wiley & Sons Inc.
4. Zinsser Microbiology, Wolfgang K. Joklik, Hilda P. Willett, D. Bernard Amos, Catherine M. Wilfert (1988), 9th ed., Prentice Hall International Inc.
5. Microbiology; An introduction, Tortura, G.J., Funke, B.R., Case, C.L. (2009), 9th ed., Pearson Education Intnl.

Biostatistics and Bioinformatics

1. Introduction to Biostatistics, Le and Chap (2009), Wilay and Sons.
2. Fundamentals of Biostatistics, B. Rosner (2005), Duxbury Press.
3. Medical Statistics from Scratch, Bowers (2008), Wiley and Sons.
4. Introduction to Bioinformatics, Arthur M. Lesk, Oxford University Press.
5. Introduction to Bioinformatics, Attwood, Pearson Education.
6. A Textbook of Systems Biology, E. Klipp, W. Liebermeister, C. Wierling, Axel Kowald, H. Lehrach, R. Herwig (2009), Wiley-VCH Verlag GmbH & Co.
7. Bioinformatics: Sequence and Genome Analysis, David W. Mount (2001), Cold Spring Harbor (CSH) Laboratory Press.
8. Plant System Biology, Coruzzi, G.M. (2009), Wiley Publishing House.

Introduction to Manuscript Writing and Research Presentation

1. Research Methods, Ram Ahuja (2014) Rawat Publications.
2. Research Methodology Methods and Techniques, C.R. Kothari (2014) New Age International.
3. Research Methodology a step by step guide for beginners (2014) Ranjit Kumar SAGE Publications India Private Limited. Third Ed.
4. Fundamental of Research Methodology and Statistics, Yogesh Kumar Singh (2006), New Age International.
5. Independent Review of Literature by students.

Lab Courses

1. Principles and Techniques of Biochemistry and Molecular Biology, K. Wilson and J. Walker (2006), Cambridge University Press.
2. An Introduction to Practical Biochemistry, D.T. Plummer (1998), Tata McGraw Hill.
3. Biochemical Calculations, I.H. Segel (2000). John Wiley and Sons Inc.
4. Practical Biochemistry, K. Wilson and J.M. Walker (1994), 6th ed.. Cambridge University Press.
5. Practical Clinical Biochemistry, Alan H. Gowenlock, Janet R. McMurray, Donald M. McLauchlan (1996), 6th ed., CBS Publishers.
6. Practical Handbook of Biochemistry and Molecular Biology, Gerald D. Fasman (1990), 3rd ed., CRC Publication.
7. Molecular Biomethods Handbook, J.M. Walker (2008), Humana Press.
8. Molecular Cloning: A Laboratory Manual (1989), 2nd ed.. Cold Spring Harbor Laboratory Press.
9. Protein Purification: Principles and Practice, Robert K. Scopes (2005), 3rd ed., Springer Advanced Texts in Chemistry.
10. Strategies for Protein Purification and Characterization, Daniel R. Marshak et.al. (1996), Cold Spring Harbor Laboratory Press.