# MSc Biochemistry Syllabus

(Approved by the BoS and Academic Council)

**Effective from July 2012**

## COURSE CONTENT

| | | Credit | Marks |
|---|---|---|---|
| **SEMESTER – I** | | | |
| Course I | MFC 001: Foundation Course* | 10 | 200 |
| Course II | MBC 101: Cell Biology | 4 | 100 |
| Course III | MBC 102: Biomolecules | 4 | 100 |
| Course IV | MBC 103: Bioenergetics and Intermediary Metabolism | 4 | 100 |
| Course V | MBC 104: Molecular Biology | 4 | 100 |
| Course VI | MBC 105: Lab Course-1 *(Analytical and separation techniques)* | 4 | 100 |
| | | 30 | 700 |
| **SEMESTER – II** | | | |
| Course VII | MBC 201: Enzymes | 4 | 100 |
| Course VIII | MBC 202: Metabolism | 4 | 100 |
| Course IX | MBC 203: Gene expression | 4 | 100 |
| Course X | MBC 204: Protein and Proteomics | 4 | 100 |
| Course XI | MBC 205: Seminar and Report Writing | 4 | 100 |
| Course XII | MBC 206: Lab Course-2 *(Enzyme analysis and immobilization techniques)* | 4 | 100 |
| | | 24 | 600 |
| **SEMESTER – III** | | | |
| Course XIII | MBC 301: Genetic Engineering | 4 | 100 |
| Course XIV | MBC 302: Clinical Biochemistry and Nutrition | 4 | 100 |
| Course XV | MBC 303: Microbiology | 4 | 100 |
| Course XVI | MBC 304: Immunology | 4 | 100 |
| Course XVII | MBC 305: Dissertation-1 *(Microbial and molecular biology techniques)* | 8 | 200 |
| | | 24 | 600 |
| **SEMESTER – IV** | | | |
| Course XVIII | MBC 401: Biotechnology and Nanotechnology | 4 | 100 |
| Course XIX | MBC 402: Computational Biochemistry and Bioinformatics | 4 | 100 |
| Course XX | MBC 403: Biochemical Techniques and Biostatistics | 4 | 100 |
| Course XXI | MBC 404: Industrial Biochemistry | 4 | 100 |
| Course XXII | MBC 405: Dissertation-2 *(Protein isolation, purification and immunological techniques)* | 8 | 200 |
| | | 24 | 600 |

**Credits in four semesters:** 102
**Total marks:** 2500

*Each paper will be taught in 50 lectures, each of one-hour duration, except for the Foundation Course where the number of lecturers will be 100. Foundation course will be coordinated by the Dean of the Faculty.*
**Course content of the Foundation Course (MFC001) is provided in Annexure-I.*

**Semester I**

**Course II**

## Cell Biology

Paper code: MBC 101

**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, its chemical composition, molecular organization, origin and evolution; prokaryotic and eukaryotic cells; cell theory and modern cell biology; cell organelles; structure and function of endoplasmic reticulum, Golgi body, endosome, lysosome, vacuole, peroxisome, ribosome, mitochondria, chloroplast, nucleus, cytoskeleton, cell wall; subcellular fractionation; cytoplasm and cytosol; methods to study the cell: principles of microscopy, centrifugation, tissue culture and flow cytometry.

**Unit II: Membrane biochemistry and function**

Membrane: chemical composition and its structural plan; membrane models; membrane as a two dimensional fluid; factors affecting the membrane fluidity; phase transition; membrane proteins; movement of small and large molecules across the cell membrane; osmosis; diffusion; endocytosis; clathrin mediated endocytosis; phagocytosis; artificial membranes.

**Unit III: Major cell functions**

Cytoplasmic membrane or endomembrane system; secretion and transport of proteins to various cell compartments; signal hypothesis; protein targeting to peroxisomes; packaging of DNA into eukaryotic chromosome; nucleosomes and higher levels of organization; nuclear pore complex; molecular trafficking; nucleolus and the synthesis of ribosome; electric properties of membrane; patch clamp and voltage clamp techniques.

**Unit IV: Signal transduction, cell cycle, cell death, stem cell and regeneration**

Receptors and ligands; transduction of signal into the cell; G protein coupled receptors; growth factors and receptor tyrosine kinase; second messengers; cell cycle and regulation; cancer; characteristics of tumor cells; mechanism of transformation; angiogenesis; tumour suppressor genes; cell signaling in development and differentiation; regulatory genes in the development of *Drosophila*; stem cell; regeneration; autophagy and cell death.

**Semester I**

**Course III**

## Biomolecules

Paper code: MBC 102

**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 and polysaccharides; structure and conformation of sugars; monosaccharides: stereoisomerism and optical isomerism; chemical reactions of the functional groups; sugar derivatives; mucoploysaccharides; glycosaminoglycans; proteoglycans; glycoproteins; glycobiology.

**Unit II: Lipids**

Classification and types of lipids; structure, nomenclature and properties of fatty acids; glycosides; soaps and detergents; structure, classification, properties and functions of phospholipids and sphingolipids; glycolipids; composition and biological role of lipoproteins; structure and functions of steroids and prostaglandins; eicosanoids; vegetable and fish oils.

**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; non-natural amino acids; structure and functions of nucleotides and alarmones; water and its physicochemical properties.

**Unit IV: Hormones**

General characteristics, classification, chemistry, functions, mechanisms and abnormalities of thyroid, parathyroid, adrenal, pancreatic, gastric and reproductive hormones; hypothalamus and pituitary; detection of hormones; hormone replacement therapy; plant hormones; pheromones.

**Semester I**

**Course IV**

## Bioenergetics and Intermediary Metabolism

Paper code: MBC 103

**Credits: 4, Lectures: 50, Maximum marks: 100 (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**

Bioenergetics: concepts, laws of thermodynamics, free energy, standard free energy; determination of $\Delta G$ for a reaction; equilibrium constant and standard free energy change; biological oxidation-reduction reactions; redox potential; relation between standard reduction potentials and free energy change; ATP as universal energy currency in biological systems; role of NADH and NADPH in metabolism; strategies to study metabolic pathways: inhibitors and radioisotope techniques.

**Unit II: Carbohydrates metabolism**

Digestion and absorption of carbohydrates; glycolysis; citric acid cycle; pentose phosphate pathway; gluconeogenesis; glucuronate pathway and their regulation; metabolism of disaccharides; biosynthesis of oligosaccharides and glycoproteins; glycogen metabolism and its regulation; glycogen storage diseases; regulation of carbohydrate metabolism; metabolic adaptation in starvation and diabetes mellitus.

**Unit III: Phosphorylation**

Electron transport chain; electron carriers and their organization; respiratory complexes; oxidative phosphorylation; sites of phosphorylation; P/O ratio; energetics of oxidative phosphorylation; inhibitors and uncouplers of oxidative phosphorylation; microsomal electron transport chain; reactions that generate and utilize ATP in the cell; substrate level phosphorylation; high-energy compounds in biological systems.

**Unit IV: Plant metabolism**

Plant-specific metabolic pathways; photosynthesis and carbon fixation; cyclic and noncyclic electron transport; $C_3$, $C_4$, and CAM pathways; photorespiration; fixation of atmospheric nitrogen and properties of nitrogenase complex; secondary metabolites and their significance; metabolism of isoprenoids; glyoxylate cycle; role of vacuole in plant metabolism.

**Semester I**

**Course V**

## Molecular Biology

Paper code: MBC 104

**Credits: 4, Lectures: 50, Maximum marks: 100 (25 Internal Assessment +75 Semester Exam)**

This course has been designed to give insight into the structure and function of nucleic acids, basic principles of genetics, molecular evolution, mechanism of DNA replication, transcription, molecular basis of mutations and site directed mutagenesis.

**Unit I: Nucleic acids**

DNA as genetic material; primary, secondary and three-dimensional structures of DNA; supercoiling; forms of DNA; polytene and lampbrush chromosomes; properties of DNA in solution; denaturation and renaturation; reassociation reactions; COT curves; types of RNAs and their primary and secondary structure; role of RNA; unusual bases in RNA.

**Unit II: Molecular evolution**

Mendelian principles: dominance, segregation, independent assortment, pleiotropy; genome imprinting; molecular evolution: separation, natural selection, and evolution of proteins and nucleotide sequences; allelic frequency; calculation of allelic frequency; molecular clocks; evolution by gene duplication and exon shuffling; deleterious genes; eugenics; gene frequencies and conservation of gene frequencies; convergent evolution.

**Unit III: Replication**

Replication of DNA and synthesis of RNA; central dogma of molecular biology; DNA and RNA polymerases and other enzymes involved in replication; mechanisms of replication; inhibitors of transcription; proof reading function and fidelity of DNA replication; possible modes of DNA replication; theta model and rolling circle model of DNA replication; replication of DNA in eukaryotes; role of methylation; replication of viral RNA; reverse transcriptase.

**Unit IV: Transcription**

Prokaryotic and eukaryotic gene structure; transposable elements in bacteria; mobile elements in eukaryotes; regulatory region and transcriptional unit of gene; post-transcriptional processing of RNA: splicing, cap addition and polyadenylation; polynucleotide phosphorylase; classification and molecular basis of mutation; Ames test and other testing systems; repair mechanism in prokaryotes and eukaryotes; site directed mutagenesis.

**Semester I**

**Course VI**

## Lab Course -1

Paper code: MBC 105

**Credits: 4, Hours: 50, 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.

### Analytical and separation techniques

1. Qualitative analysis of carbohydrates, lipids, amino acids, and proteins from biological sample
2. Quantitative (spectrophotometric) analysis of glucose, cholesterol, protein, and nucleic acid
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 the plant material and determination of its saponification and iodine number
9. Centrifugation technique: subcellular fractionation, and isolation of nuclei and mitochondria from the tissue
10. Immobilization of cell: RBC/yeast
11. Nanodrop (Demonstration only)

**Semester II**

**Course VII**

## Enzymes

Paper code: MBC 201

**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; non-enzymatic biochemical reactions.

**Unit II: Enzyme kinetics and enzyme inhibition**

Kinetics of enzyme catalyzed reactions; steady-state hypothesis and derivation of Michaelis-Menten equation; significance of $K_m$ and $V_{max}$ 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 $K_i$; 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.

**Semester II**

**Course VIII**

## Metabolism

Paper code: MBC 202

**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 first semester where the metabolism of lipids, amino acids and nucleotides were 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 the non-enzymatic reactions in the body and their significance. Beside this, toxicity of various pollutants and their impact on metabolism in particular and organism as a whole have also been focused.

**Unit I: Lipid metabolism**

Dietary lipids: digestion, absorption and metabolism; main and alternative pathways of fatty acid oxidation; oxidation of odd carbon number and unsaturated fatty acids; biosynthesis of saturated and unsaturated fatty acids; metabolism of triacylglycerols, phospholipids, glycolipids, sphingolipids and cholesterol; formation of ketone bodies and their oxidation; leptons; fatty acid biosynthesis in plants; lipoprotein metabolism.

**Unit II: Amino acid metabolism**

Digestion of proteins and absorption of amino acids; general reactions in the degradation of amino acids; deamination and transamination reactions; urea cycle; fate of the carbon skeleton of amino acids; essential and nonessential amino acids; biosynthesis of individual amino acids; regulation of amino acid biosynthesis; inborn errors of amino acid metabolism.

**Unit III: Nucleic acid metabolism**

Degradation of nucleic acids; deoxyribonucleases and ribonucleases; biosynthesis and degradation of purine and pyrimidine nucleotides; regulation of purine and pyrimidine nucleotide metabolism; biosynthesis of deoxyribonucleotides; interconversion of nucleotides; inborn errors of nucleotide metabolism; biosynthesis of nucleotide coenzymes; metabolism of porphyrins.

**Unit IV: Xenobiotic metabolism and environmental biochemistry**

Metabolism and toxicity assessment of xenobiotics; environment and pollution; pollutants and cellular metabolism; biotransformation; drug metabolizing enzymes; eutrophication; biomagnifications; biochemical effects of As, Cd, Pb, Hg, Co, $NO_x$, $SO_x$, $O_3$, cyanide, hydrocarbons, particulate matter, pesticides and other common pollutants; green house effect; global warming and consequences on plant and animal metabolism.

**Semester II**

**Course IX**

## Gene Expression

Paper code: MBC 203

**Credits: 4, Lectures: 50, Maximum marks: 100 (25 Internal Assessment +75 Semester Exam)**

This course is intended to teach students the gene expression and translational regulatory mechanisms. After the delivery of the lectures, students will have an understanding of control of gene expression in eukaryotes and prokaryotes, concepts of translation, post-translational modification of proteins, proteolytic processing and protein targeting to various cellular compartments.

**Unit I: Gene expression and its regulation**

Gene expression in prokaryotes; enzyme induction and repression; negative and positive control; concept of operon; catabolic repression; transcriptional termination control via mRNA alternative conformations; regulation of gene expression in eukaryotes; promoters, enhancers and response elements; regulation at transcriptional level: Britten Davidson model; control by steroid hormones.

**Unit II: Translation and its control**

Translation; adapter role of RNA in protein synthesis; size of the code; methods of deciphering the genetic code; code word dictionary; general features of the genetic code; identification of anticodons; wobble hypothesis; ribosome as the site of protein synthesis; polysomes; activation of amino acids; initiation, elongation and termination of protein synthesis in prokaryotes and eukaryotes.

**Unit III: Posttranslational modifications**

Control of translation: role of guanine nucleotides; post-translational processing of the polypeptide chains; acylation, methylation, phosphorylation by protein kinases; sulfation; glycosylation; role of vitamins; role of chromatin structure in gene expression; cytoplasmic regulation of gene expression; organelle genome; epigenetics.

**Unit IV: Proteolytic processing and targeting**

Proteolytic processing and protein degradation; inhibitors of protein biosynthesis; eukaryotic protein sorting and translocation; protein biosynthesis in mitochondria and chloroplast; protein targeting-vesicles; clathrin coated vesicles; targeting of vesicles to various cell compartments; proteasome.

**Semester II**

**Course X**

## Proteins and Proteomics

Paper code: MBC 204

**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 mass spectrometry including MALDI-TOF, ESI-MS, MS/MS and X-ray crystallography for prediction of three-dimensional structure of protein.

**Unit I:** **Primary structure of protein**

An overview of protein structure; globular and fibrous proteins; hierarchy of protein structure; dihedral angles; Ramachandran plot; determination of N and C-terminal residues; determination of amino acid composition of protein and determination of sulfhydryl groups; location of disulfide bonds; fingerprinting; chemical synthesis of peptides; structure and function of some biologically important polypeptides.

**Unit II:** **Secondary and tertiary structure of proteins**

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; determination of molecular weight of proteins; protein purification; criteria of purity, and fold purification.

**Unit III:** **Sequencing, protein folding, and denaturation**

Protein sequencing; sequenators; hydropathy index; quaternary structure of proteins; structure and function of hemoglobin and cytochrome *c*; characteristics of molten globule state; proteins involved in folding; *in vivo* folding; models of protein folding; chaperones; protein conformation and diseases; neurodegenerative diseases.

**Unit IV:** **Proteomics**

Overview and tools; 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; X-ray crystallography; transmembrane domains; functional proteomics; application of proteome analysis.

**Semester II**

**Course XI**

## Seminar and Report Writing

Paper code: MBC 205

**Credits: 4, Hours: 50, Maximum marks: 100 (25 Internal Assessment +75 Semester Exam)**

This course is aimed at to inculcate in student the habit of reading, thinking, planning, developing ideas, search literature and retrieve information, preparation of scientific reports, and order of paragraph writing, besides the proper use of nouns, pronouns, articles, tenses and spelling, and preparation of presentation and delivering seminar with clarity of objectives, design, parameters, data interpretation, summary and conclusion.

### The course content

Student under the mentorship of a teacher would be asked to identify a research publication on the topic of his choice published in a high impact factor journal, understand it and present the findings in her/his own way. Seminar will be delivered using power point, and the contents of the lecture will be submitted to the department in the form of a report, and will be evaluated by a committee constituted by the Head of the Department. At the end of the semester, student will be required to submit the technical report, which will be evaluated by an external examiner who will be called for the *viva voce*. Internal evaluation will be based on the presentation, content, time management and ability to respond to audience questions as well as attendance and ability to question while attending seminars of other students in the presence of teachers of the department.

**Semester II**

**Course XII**

## Lab Course-2

Paper code: MBC 206

**Credits: 4, Time: 50 hr, Maximum marks: 100 (25 Internal Assessment +75 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. Teacher supervising the course will be explaining the principle, theory and instrumentation of the technique to be used before starting the practical exercise.

**Enzyme analysis and immobilization techniques**

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

**Semester III**

**Course XIII**

## Genetic Engineering

Paper code: MBC 301

**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; 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.

**Semester III**

**Course XIV**

## Clinical Biochemistry and Nutrition

Paper code: MBC 302

**Credits: 4, Lectures: 50, Maximum marks: 100 (25 Internal Assessment +75 Semester Exam)**

This paper is aimed at to familiarize the student the concepts of clinical and nutritional biochemistry. The paper 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 deficiency disorders related to nutritional imbalances and its impact on overall health and health related disorders, and gives an introduction to nutrigenomics.

### PART-A: Clinical Biochemistry

**Unit I: Clinical biochemistry and quality assurance**

Clinical chemistry; biological samples: types, collection, processing, stability and storage; phlebotomy tubes; serum separator devices; chemical composition of the 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; clinical research; responsibilities of a clinical biochemist.

**Unit II: Biochemical tests in clinical medicine**

Biochemical tests in clinical medicine: uses; 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 liver and kidney; bilirubin metabolism and hyperbilirubinaemia; acid base disorders.

### PART-B: Nutritional Biochemistry

**Unit III: Nutrition in health and diseases**

Protein energy malnutrition; energy requirements: basal metabolic rate (BMR); factors affecting BMR and its measurement; resting metabolic rate; specific dynamic action of food; dietary fat, 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.

**Unit IV: Nutritional requirements**

Basic concepts, scope and methodology; principal food components; vitamins: structure and function; food nutrients: classification and distribution; recommended allowances and their modifications under stress conditions; deficiency and excess of principal nutritional components; formula diets and crash diets; balanced diets; dietary standards: EAR, RDA, ADI, DRV, DRI, TUL etc; water as an essential nutrient; food preservatives; additives and anti-nutrients; toxic effects of food: sources, active agents and effects.

**Semester III**

**Course XV**

## Microbiology

Paper code: MBC 303

**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, including the primary differences between the prokaryotic and eukaryotic forms of life, differences within prokaryotes and eukaryotic microorganisms, various techniques used to study the growth and other characteristics, classification and genetics of microorganisms and viruses, and the positive and negative impact of these agents on humans. The paper also includes the concept of the impact of microorganisms on the environment and the ways these organisms may be used in de-polluting the environment.

**Unit I:** **Microorganisms and a-cellular infectious agents**

Prokaryotic and eukaryotic microorganisms; general characteristics of bacteria, algae, fungi and protozoa; salient features of major divisions; animal and plant diseases caused by microorganisms; normal human microbiota; general characteristics of virions; viruses of eukaryotes: isolation and cultivation; bacteriophages; one-step growth curve; replication of DNA and RNA viruses; viral infections; antiviral chemotherapy; viral interference; virusoids, viroids and prions.

**Unit II:** **Eubacteria and archaebacteria**

Characteristics and criteria used in the classification of bacteria; bacterial taxonomy; numerical taxonomy; staining procedures; selective and differential staining; Gram staining and acid-fast staining; general characteristics of major groups of prokaryotes; evolutionary relationships between eubacteria, archaebacteria and eukaryotes.

**Unit III:** **Microbial growth and genetics**

Microbial nutrition; culture media; bacterial growth curve and measurement of growth; control of microorganism by physical and chemical agents; antimicrobial agents: structure and mechanisms; antiviral agents; identification and isolation of bacterial mutants; bacterial and phage genetics; gene transfer in bacteria: conjugation, transformation and transduction; molecular mechanism of recombination; mapping the structure of bacterial chromosome; lysogeny and lytic cycle in bacteriophage.

**Unit IV:** **Environmental microbiology**

Microbial diversity; microbial communities; interaction of microorganisms with environment; microorganisms as primary producers in the presence and absence of sunlight; biogeochemical cycles of important nutrients; biomarkers of environmental exposure; bio-pollutants; bioremediation; animal-microbe and plant-microbe interactions; biological treatment of solid and liquid wastes and pollutants; microorganisms and bioleaching; recovery of metals and oil; probiotic and prebiotic.

**Semester III**

**Course XVI**

## Immunology

Paper code: MBC 304

**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, biochemistry of immune responses and immune-mediated diseases, and introduce immunotechnology.

**Unit I: Types of immunity**

Humoral and cellular immunity; clonal selection theory; cells and organs of immunity: primary and secondary lymphoid organs; T and B cells; macrophages and effecter cells; macrophage plasticity; primary and secondary immune response; Immunological memory; antigens; immunogens; antigen antibody interactions; immunoglobulins: types and structure; CDRs; immunoglobulin fold; isotypes, allotypes and idiotypes; valency, affinity and avidity.

**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; T-cell receptor; antigen processing, antigen presentation; products and factors produced by T-cell activation; dendritic cells; cytokines and chemokines; B cell activators; B-cell and helper T-cell subset interactions; cytotoxic T-cell mediated killing.

**Unit III: Immune-mediated diseases**

Tolerance and autoimmunity; immunoregulation; immune response to infectious diseases; viral, bacterial and protozoal infections; H1N1; cancer immunotherapy; mucosal immunity; adjuvants and vaccines; active immunization (immunoprophylaxis); complement and mechanism of complement fixation; immunological tolerance; hypersensitivity reactions.

**Unit IV: Immunotechnology**

Immunoprecipitation; agglutination; immunoelectrophoresis; RIA; immunofluorescence; cytotoxicity assay; ELISPOT; ELISA; Western blotting; hybridomas and their production; immunization protocol; confocal microscopy; whole body imaging.

**Semester III**

**Course XVII**

## Dissertation-1

**(Microbial and Molecular Biology Techniques)**

Paper code: MBC 305

**Credits: 8, Time: 200 hr, Maximum marks: 100 (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 on microbial and molecular biology techniques**

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)

The performance of the student will be evaluated on the basis of internal assessment by the concerned teacher, and final assessment will be done by a committee constituted by the Head of the Department. Student will be required to submit the dissertation duly signed by the supervisor/s to the Head of the Department and will bring a copy of the dissertation at the time of viva towards the end of the semester.

**Semester IV**

**Course XVIII**

## Biotechnology and Nanotechnology

Paper code: MBC 401

**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; mapping genome; 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; bioindicators; environmental monitoring; biopesticides; biocontrol; food chains and biomagnification; biological mining; biofuel; landfills and vermin composting; environment and transgenics; biofertilizers; production of technology for major biofertilizers; ethical, social and biosafety aspects of biotechnology; biological containment.

**Unit IV: Nanotechnology**

Nanotechnology and its applications in biosciences: basics only; 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.

**Semester IV**

**Course XIX**

## Computational Biochemistry and Bioinformatics

Paper code: MBC 402

**Credits: 4, Lectures: 50, Maximum marks: 100 (25 Internal Assessment +75 Semester Exam)**

The objective behind this course is to familiarize the student with the use of computers in understanding life processes, and to make them aware of the databases such as PDB, retrieve information and use appropriate tools for data analysis, besides providing a working knowledge of computer science.

**Unit I: Computer science**

Computer: introduction, capabilities and applications; hardware and software; memory/storage devices; operating systems (OS): multiprogramming OS, time-sharing OS; UNIX; MS office; basics of programming languages: PERL, C, python, script; basics of data structure, database management; computer network; transfer of network data; privacy and security issues.

**Unit II: Computational biochemistry**

Computational fundamentals and data design; structural database; biochemical data management and analysis of biochemical data with spreadsheet application; structural biology, molecular modeling and simulation; disease modeling; methods to study 3D structures; computer graphics and representation of molecular structures; pathway prediction software; systems biology: flux analysis, network reconstruction and graph based analysis; synthetic biology.

**Unit III: Bioinformatics**

Bioinformatics: introduction, emerging, 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; restriction enzyme mapping; identification of open reading frames (ORF); gene annotation technology; *in silico* methods for identification of vaccine/drug target.

**Unit IV: Applications of bioinformatics**

Computational methods for sequence analysis; phylogenetic analysis; comparative genomics; numerical taxonomy; virtual and electronic cell; internet tools for DNA sequence translation; protease digestion mapping; prediction of signal peptide, secondary structure and phosphorylation sites; application tools: primer designing; tools for molecular mapping; computer aided drug designing; QSAR; docking; search and analysis of enzyme data; receptor biochemistry; interlinking of pathways.

**Semester IV**

**Course XX**

## Biochemical Techniques and Biostatistics

Paper code: MBC 403

**Credits: 4, Lectures: 50, Maximum marks: 100 (25 Internal Assessment +75 Semester Exam)**

This course has been designed to introduce the student the fractionation and spectroscopic techniques, their principles and applications. The course, divided into two parts, also provides an insight into the fundamentals of statistics and its application in biochemistry.

### PART A: Biochemical techniques

**Unit I: Methods for biochemical fractionation**

Chromatography: general principles, types and techniques; partition, size exclusion, ion exchange, and affinity chromatography; IMAC; GLC; electrophoresis and isoelectric focusing; centrifugation: preparative and analytical; types of rotors.

**Unit II: Spectroscopic techniques**

Spectroscopic techniques: principles and applications in the study of biomolecules; spectrofluorometry; infrared spectrophotometry; atomic absorption spectroscopy; NMR spectrometry; ORD; CD; ESR spectroscopy; Raman spectroscopy; electron microscopy.

### 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; properties; correlation: types and methods; simple, multiple, linear and non linear 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.

**Semester IV**

**Course XXI**

## Industrial Biochemistry

Paper code: MBC 404

**Credits: 4, Lectures: 50, Maximum marks: 100 (25 Internal Assessment + 75 Semester Exam)**

The primary objective of this paper is to make the student aware of the importance of biochemistry as an applied science, and make him able to understand various aspects of industrial applications of biochemistry, particularly in pharmaceutical and food industry. In view of this, the paper revolves around the various uses and applications of biochemistry in industry and provides an insight into the processes already applied at the commercial level as well as the prospects of up-scaling of processes, currently feasible at lab-scale, to the commercial level. The course introduces basics of chemical engineering, bioprocess design and scale up as well as includes lectures on IPR and GATT issues.

**Unit I: Basics of chemical engineering, bioprocess design and scale up**

Basics of chemical engineering; mass transfer; heat generation and removal; fluid dynamics: Bernoulli's principle; viscosity; hydraulic conductivity; capillary flow; control and applications of industrial processes; process evaluation and development; over production of metabolites and methods; downstream processing; gene dosage and its applications in industrial processes.

**Unit II: Pharmaceutical biochemistry and vaccine development**

Development of new drug/molecules and elucidation of their mechanisms of actions; formulations; pharmacokinetics and pharmacodynamics; factors affecting drug efficacy; drug resistance; traditional medicines; biotransformation; large scale production of humanized monoclonal antibodies; vaccine development.

**Unit III: Food biochemistry**

Introduction to different categories of food; constituents of food products and their functional properties; introduction to food processing; intermediate moisture food; food spoilage; intrinsic and extrinsic factors affecting the quality and life of food material; food storage and preservation techniques; food poisoning and intoxication; by-product utilization and scale up; molasses and alcohol production.

**Unit IV: Industrial uses of enzymes and other biomolecules, IPR and GATT**

Industrial production of enzymes from traditional sources and genetically engineered organisms; proteases; carbohydrases; lipases and their applications; enzymes for analytical applications; industrial uses of seed oils; vaccine/protein production by rDNA technology: large scale isolation and purification; downstream processing and scale up; biosafety; biological containment; biosafety levels; patenting; intellectual property rights (IPR); general agreement on trade and tariff (GATT).

**Semester IV**

**Course XXII**

## Dissertation-2

**(Protein Isolation/Purification and Immunological Techniques)**

Paper code: MBC 405

**Credits: 8, Time: 200 hr, Maximum marks: 100 (50 Internal Assessment +75 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. Purification of protein (egg albumin) from hen egg white
2. Salt fractionation, dialysis, gel filtration, and ion-exchange chromatography
3. Spectroscopic analysis of ovalbumin and determination of absorption spectrum and quantitative estimation
4. Polyacrylamide gel electrophoresis of the purified egg protein in the absence or presence of SDS to check purity of the preparation
5. Determination of molecular weight of ovalbumin by gel filtration and SDS-PAGE
6. Immunization of experimental animals with the purified ovalbumin and detection of antibodies in antiserum; immunodiffusion
7. Isolation of immunoglobulin from the antiserum
8. Isoelcetric focusing and 2D electrophoresis (Demonstration only)

Performance of the student will be evaluated on the basis of internal assessment by the concerned teacher, and the final assessment will be done by a committee constituted by the Head of the Department. Student will be required to submit the dissertation duly signed by the supervisor/s to the Head of the Department and will bring a copy of the dissertation at the time of viva towards the end of the semester.

ANNEXURE-1

## Semester I

### Foundation Course

Paper code: MFC 001

**Credits: 10, Lectures: 100 hr, 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 programme 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.

OFFICE OF THE DEAN
FACULTY OF SCIENCE, JAMIA HAMDARD

F. No. JH/FS/DO/FC/221 Dated: 14.05.2010

**FOUNDATION COURSE**

**Unit I CHEMISTRY**

**Essential:**

1. Solution – Methods of expressing the concentration (Molality, Moarlity, Normality etc). Collagative properties, Molecular mass determination using colligative properties, basics of Nanotechnology.
2. Rate of reaction, order of reaction, molecularity of reaction.
3. 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.
4. Principle of Chromatography, Classification of chromatographic techniques, TLC and paper chromatography, Application of chromatography
5. Basics of Spectroscopy and applications.

**Desirable:**

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

**Unit II BIOCHEMISTRY**

**Essential:**

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

**Desirable:**

1. **Gene transfer Mechanisms in bacteria & Gene expression:** Conjugation, Transformation and Transduction; expression of eukaryotic genes in prokaryotes.
2. **Clinical Biochemistry:** Biochemical tests; Quality assurance; Acid base disorders; Liver function test; Kidney function tests.

3. **Glucose Metabolism:** Glycolysis and TCA cycle; oxidative phosphorylation; Aerobic & anaerobic Fermentation.
4. **Hybridoma technology**

**Unit III BOTANY**

**Essential:**

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

**Desirable:**

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

**Unit IV BIOTECHNOLOGY**

**Essential:**

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

**Desirable:**

1. **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.
2. **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:**

1. **Introduction to Toxicology:**
   (i) Various types of toxicity (Acute, subacute, subchronic and chronic).
   (ii) Chemical interactions (Additive effect, potentiation, synergism and antagonism), Dose response relationship ($ED_{50}$, $LD_{50}$ $EC_{50}$, $LC_{50}$.)
   (iii) Routes of exposure, absorption, distribution, elimination. *In vitro* and *in vivo* models in toxicological studies.
2. **Metabolism of xenobiotics:** Common toxicants of air, water & food - metabolism & impact on human health.
3. Concept and requirement of Good Laboratories Practices (GLP), GMP, GCP.

**Desirable:**

1. Tumor Markers
2. Chemical carcinogenesis & dietary intervention
3. Enzyme inhibitor