

## ***SYLLABUS***

**The course contents are outlined below:**

### **A. Cognitive Domain**

#### **Paper I**

**Biomolecules, Principles of Biophysics and its biomedical importance, Cell biology, Fluid, electrolyte and acid-base balance, Analytical techniques and instrumentation, Biostatistics and research methodology, Basics of medical education in teaching and assessment of Biochemistry.**

### **BIOMOLECULES**

Ionization of water, the concept of acid and base, weak acids and bases, pH, pK, Henderson-Hasselbalch equation, buffer and buffering capacity.

#### **Proteins:**

- Classification, structure, properties and functions of amino acids and peptides, biologically important peptides,
- Classification, biological significance and structural organization of proteins,
- Structure-function relationship of proteins (haemoglobin, myoglobin, collagen and immunoglobulins),
- Fractionation, purification, structural analysis and characterization of proteins,
- Protein folding and its associated disorders,
- Protein denaturation,
- Protein degradation – lysosomal and proteosomal,
- Plasma proteins.

#### **Carbohydrates:**

- Classification, biomedical importance, functions, properties and reactions of carbohydrates,
- Structural aspects of monosaccharides, disaccharides and polysaccharides,
- Mucopolysaccharides/glycosaminoglycans, glycoproteins and glycolipids,
- Glycation, glycosylation and role of carbohydrates in blood group substances.

#### **Lipids:**

- Types, properties and biomedical importance of lipids,
- Fatty acids - nomenclature, classification, properties, reactions including essential fatty acids, polyunsaturated fatty acids and trans fatty acids,
- Mono, di- and triacylglycerols,
- Trans fats,

- Cholesterol - structure, properties and biomedical importance,
- Phospholipids – classification, properties, composition, and biomedical importance of various phospholipids,
- Glycolipids – classification, properties, composition, and biomedical importance,
- Lipoproteins – classification, properties, composition, and functions of various lipoproteins including the role of apoproteins, their importance in health and disease,
- Role of lipids in the structure and function of biological membranes,
- Structure, properties, and biomedical applications of micelles and liposomes.

#### **Nucleotides and nucleic acids:**

- Purine and pyrimidine bases in DNA and RNA,
- Nucleosides and nucleotides,
- Biologically important nucleotides (including synthetic analogs of purine/pyrimidine bases and nucleosides used as therapeutic agents),
- Structure, functions, properties, and types of DNA and RNA.

#### **PRINCIPLES OF BIOPHYSICS AND ITS BIOMEDICAL IMPORTANCE**

- Diffusion, osmosis, dialysis, surface tension, viscosity, colloids, crystalloids, and suspensoids.

#### **CELL BIOLOGY**

- Structural organization and functions of a biological cell and different subcellular organelles along with their marker enzymes,
- Molecular organization, functions, and structure-function relationship of a cell membrane,
- Solute transport across biological membranes with related disorders,
- Cell fractionation and separation of organelles,
- Disorders related to cell membrane and subcellular organelles,
- Intracellular traffic and sorting of proteins,
- Intracellular signaling pathways, membrane receptors and second messenger,
- Intercellular junctions, cellular adhesion molecules, intercellular signaling and communication,
- Extracellular matrix: composition, and biomedical importance,
- Components of the cytoskeleton, and their role in muscle contraction and cell motility,
- Cell cycle, its regulation, and mechanism of cell death,
- Structure and functions of specialized cells.

## **FLUID, ELECTROLYTE, AND ACID-BASE BALANCE**

- Fluid, electrolyte, and acid-base balance, mechanism of regulation and associated disorders.

## **ANALYTICAL TECHNIQUES AND INSTRUMENTATION**

- Colorimetry,
- Spectrophotometry,
- Atomic absorption spectrophotometry,
- Flame photometry,
- Fluorometry,
- Turbidimetry and nephelometry,
- Gravimetry,
- Electrochemistry (pH electrodes, ion-selective electrodes, gas-sensing electrodes, enzyme electrodes),
- Chemical sensors (biosensors),
- Osmometry,
- Chemiluminescence,
- Water quality testing (TDS, pH, fluoride) for autoanalyzer,
- Electrophoresis (principle, types, applications; isoelectric focusing, capillary electrophoresis; 2-D electrophoresis),
- Chromatography [principle, types (including high-performance liquid chromatography and gas chromatography)],
- Mass spectrometry,
- Immunochemical techniques,
- Techniques in molecular biology,
- Nanotechnology and microfabrication,
- Techniques to study *in vivo* metabolism (NMR, SPECT, PET scan, etc.),
- Radioisotope-based-techniques and their applications (permissions, precautions, management of radioactive waste),
- Automation,
- Point-of-care testing.

## **BIOSTATISTICS AND RESEARCH METHODOLOGY**

- Basic concepts of biostatistics as applied to health science,
- Statistical tests: t-test, analysis of variance, chi-square test, non-parametric tests, correlation and regression,
- Statistical methods of validation of diagnostic tests,
- Types of study designs and sampling methodologies,
- Meta-analysis and systematic reviews,
- Planning and management of research,
- Electronic search of the literature,
- Ethical aspects related to research and publication,
- Brief introduction of software for data analysis,
- Essentials of intellectual property rights, patents and copyrights.

## **BASICS OF MEDICAL EDUCATION IN TEACHING-LEARNING AND ASSESSMENT OF BIOCHEMISTRY**

- Group dynamics,
- Principles of adult learning, the taxonomy of learning,
- Curriculum planning,
- Educational objectives,
- Developing a lesson plan (appropriate to the objective and teaching learning method),
- Interactive and innovative teaching methods for large and small groups,
- Use of appropriate media (for a learning session),
- Principles of self-directed learning and giving feedback,
- Framing appropriate essay questions, short answer questions and multiple-choice questions,
- Item analysis and preparation of question bank,
- Principles and types of assessment,
- Methods of assessing cognitive skills, psychomotor skills, communication skills, and professionalism (including viva voice and OSPE),
- Developing a plan for internal assessment and formative assessment,

- Preparation of blueprint and setting of question paper,
- Microteaching,
- Reflection writing.

## **Paper II**

**Enzymes, Bioenergetics, Biological oxidation, Intermediary metabolism and inborn errors of metabolism, Nutrition, Vitamins and Minerals, Detoxification and metabolism of xenobiotics, Free radicals and anti-oxidant defense systems**

### **ENZYMES**

- Properties, classification, mechanism of action, coenzymes and cofactors, proenzymes, ribozymes, nanozymes, catalytic antibodies,
- Factors affecting the rate of enzyme-catalyzed reaction,
- Kinetics of enzyme activity, regulation of enzyme activity,
- Isoenzymes and isoforms, role in metabolic regulation,
- Enzyme inhibition,
- Principles of enzyme assays,
- Applications of enzymes: diagnostic, therapeutic and commercial uses of enzymes,
- Enzymes as targets for drug development.

### **BIOENERGETICS**

- Basic concepts of thermodynamics and its laws, as applicable to living systems,
- Exergonic and endergonic reactions and coupled reactions, redox potential,
- High energy compounds,
- Enzymes of biological oxidation,
- Cytochromes.

### **BIOLOGICAL OXIDATION**

- Components, complexes and functioning of the respiratory chain including inhibitors,
- Process and regulation of oxidative phosphorylation including uncouplers,
- Mechanisms of ATP synthesis and regulation,
- Mitochondrial transport systems and shuttles,
- Mitochondrial diseases.

## **INTERMEDIARY METABOLISM AND INBORN ERROR OF METABOLISM**

### **Metabolism of carbohydrates:**

- Digestion and absorption including associated disorders,
- Glycolysis and TCA (Kreb's cycle), including regulation,
- Glycogen metabolism and its regulation,
- Cori cycle, gluconeogenesis,
- Metabolism of fructose and galactose and their clinical significance,
- Pentose phosphate /HMP shunt pathway and uronic acid pathways and their clinical significance,
- Polyol/sorbitol pathway,
- Regulation of blood glucose, hyperglycemia, hypoglycemia and their clinical significance,
- Glucose tolerance test and its interpretation,
- Diabetes mellitus – classification, pathogenesis, metabolic derangements and complications, diagnostic criteria and laboratory investigations, principles of treatment (including diet and lifestyle modification),
- Inborn errors and disorders of carbohydrate metabolism.

### **Metabolism of Lipids:**

- Digestion and absorption and associated disorders,
- Metabolism of fatty acids, regulation and related disorders,
- Metabolism of eicosanoids and their clinical significance,
- Metabolism of triacylglycerol, storage and mobilization of fats,
- Metabolism of adipose tissue and its regulation,
- Metabolism of cholesterol including its transport and hypercholesterolemia,
- Metabolism of lipoproteins, atherosclerosis, fatty liver and lipid profile,
- Metabolism of methanol and ethanol,
- Role of liver in lipid metabolism,
- Metabolism of phospholipids and associated disorders,
- Metabolism of glycolipids and associated disorders,
- Inborn errors of lipid metabolism.

### **Metabolism of amino acids and proteins:**

- Digestion, absorption and associated disorders,
- Deamination, transamination, disposal of the amino group, catabolism of the carbon skeleton of amino acids,
- Formation and disposal of ammonia (including urea cycle) and related disorders, ammonia toxicity,
- Metabolism of individual amino acids and associated disorders,
- One carbon metabolism,
- Biogenic amines,
- Inborn errors of amino acid metabolism.

### **Metabolism of nucleotides:**

- Metabolism of purines and pyrimidines and their associated disorders.

### **Metabolism of haem:**

- Metabolism of haem and associated disorders.

### **Interorgan and intraorgan interrelationships and integration of metabolic pathways:**

- Metabolic adaptation in starvation, diabetes mellitus, obesity, and during exercise.

## **NUTRITION**

- Calorific value, Basal Metabolic Rate (BMR), Specific dynamic action (SDA) of food.
- Nutritional importance of proximate principles of food including sources and RDA.
- Glycemic index.
- Biological value of proteins and nitrogen balance.
- Thermogenic effect of food.
- General nutritional requirements.
- Balanced diet, diet formulations in health and disease, mixed diet.
- Calculation of energy requirements and prescribing diet.
- Nutritional supplements and parenteral nutrition.
- Food toxins and additives.

- Disorders of nutrition, obesity, protein energy malnutrition, under-nutrition and laboratory diagnosis of nutritional disorders.
- National Nutrition Programme.

### **VITAMINS AND MINERALS**

- Structure, functions, sources, RDA, and metabolism of vitamins and minerals and their associated disorders.

### **DETOXIFICATION AND METABOLISM OF XENOBIOTICS**

### **FREE RADICALS AND ANTI-OXIDANT DEFENSE SYSTEMS**

- Free radicals and anti-oxidant defense systems in the body.
- Associations of free radicals with disease processes.
- Oxygen toxicity.
- Oxidative stress markers in blood, urine, and other biological fluids.

### **Paper III:**

### **Molecular biology, Molecular and genetic aspects of cancer, Immunology, and Environmental Biochemistry**

### **MOLECULAR BIOLOGY**

#### **Structure and organization of chromosomes and chromatin re-modeling**

#### **DNA replication:**

- DNA replication in prokaryotes and eukaryotes (including important differences between the two).
- End replication problem: Telomere, telomerase and their role in health and disease.
- DNA repair mechanisms and their associated disorders.
- Inhibitors of DNA replication and their clinical significance.
- DNA recombination.
- DNA protein interaction.



## **Transcription:**

- Structure of a gene - exons and introns, promoter, enhancers/repressors and response elements.
- Process of transcription in prokaryotes and eukaryotes.
- Post-transcriptional modifications.
- Inhibitors of transcription.
- RNA editing and stability.

## **Genetic code, gene polymorphism, and mutation:**

- Characteristics of the genetic code.
- Molecular basis of the degeneracy of the genetic code (Wobble hypothesis).
- Mutation and gene polymorphism.
- Mutagens- examples of physical, chemical, and biological mutagens.
- Types of mutations.
- Mutation in health and disease.

## **Translation:**

- Basic structure of prokaryotic and eukaryotic ribosomes.
- Process of protein synthesis (translation) in prokaryotes and eukaryotes.
- Post-translational modifications.
- Protein sorting, protein targeting, protein folding and related disorders.
- Inhibitors of translation in prokaryotes and eukaryotes, and their clinical significance.

## **Regulation of gene expression in prokaryotes and eukaryotes**

## **Recombinant DNA technology and its applications in modern medicine**

## **Overview of human genome project**

## **Basics of bioinformatics**

## **Principles of human genetics:**

- Alleles, genotypes and phenotypes.
- Patterns of inheritance: monogenic and polygenic inheritance.
- Population genetics.

- Genetic factors in causation of diseases.
- Types of genetic diseases: Chromosomal, monogenic and polygenic disorders, mitochondrial disorders, nucleotide repeat expansion disorders, imprinting disorders.
- Screening for genetic diseases and prenatal testing.
- Ethical and legal issues related to medical genetics.

#### **Stem cells and regenerative medicine:**

- Basic concepts regarding stem cells
- Types of stem cells: embryonic and induced pluripotent stem cells (IPSC)
- Application in regenerative medicine and disease therapeutics
- Ethical and legal issues related to use of stem cells in medicine.

#### **MOLECULAR AND GENETIC ASPECTS OF CANCER**

- Biochemical characteristics of a cancer cell
- Biochemistry of carcinogenesis
- Carcinogens
- Role of oncogenes and tumor suppressor genes
- Genetic alterations and adaptations in cancer
- Tumor markers, cancer risk assessment, and community screening
- Biochemical basis of cancer chemotherapy and drug resistance
- Anti-cancer therapy.

#### **IMMUNOLOGY**

- Organization and components of the immune system
- Innate and adaptive immunity- components and functions
- Antigens, immunogens, epitopes and haptens, carriers, adjuvants
- Immunoglobulin: structure, types, and functions
- Mechanism of antibody diversity: organization and expression of immunoglobulin genes, immunoglobulin gene rearrangement, class switching
- Humoral and cell-mediated immunity, regulation of immune responses, immune response to infections
- Major histocompatibility complex, antigen processing, and presentation

- Antigen-antibody interaction, immune effector mechanisms
- Complement system
- Hypersensitivity reactions
- Tolerance, autoimmunity
- Immunodeficiency, immune unresponsiveness, and their clinical implications
- Vaccines
- Immunology of chronic diseases
- Transplantation immunology
- Immunodiagnostics and immunotherapy.

## **ENVIRONMENTAL BIOCHEMISTRY**

Health and pollution

Effects of environmental pollutants on the body

### **Paper IV**

**Basic principles and practice of clinical biochemistry, Biochemical analytes, Assessment of organ system functions, and Recent advances in biochemistry**

## **BASIC PRINCIPLES AND PRACTICE OF CLINICAL BIOCHEMISTRY**

- Units of measurement, reagents, clinical laboratory supplies, basic separation techniques, laboratory calculations, specimen collection, transport and processing, safety in the laboratory,
- Essentials of clinical investigations in Biochemistry, the clinical utility of laboratory tests (including accuracy, precision, sensitivity, specificity, ROC curves, etc), analysis in the laboratory, and selection and evaluation of methods (including statistical techniques),
- Evidence-based laboratory medicine, establishment and use of reference values, pre-analytical, analytical, and post-analytical variables and biological variations, total quality management (TQM), clinical laboratory and hospital informatics, concepts and reporting of critical values.

## **BIOCHEMICAL ANALYTES**

**Biochemical analyses and their clinical significance:**

- Amino acids, peptides and proteins; non-protein nitrogenous compounds
- Enzymes

- Carbohydrates
- Lipids, lipoproteins and apolipoproteins and other cardiovascular risk markers
- Electrolytes
- Blood gases and pH
- Hormones
- Catecholamines, serotonin, and other neurotransmitters
- Vitamins, minerals, trace and toxic elements
- Hemoglobin, and bilirubin
- Porphyrins
- Bone markers
- Tumour markers.

### **Body fluid analysis**

### **Stone analysis**

### **Therapeutic drug monitoring**

### **Clinical toxicology**

### **Pharmacogenomics**

### **Pediatric and geriatric biochemical investigations**

- Biochemistry of aging

## **ASSESSMENT OF ORGAN SYSTEM FUNCTIONS**

### **Hematopoietic disorders:**

- Hemostasis and thrombosis-biochemical mechanism, related laboratory tests, antiplatelet therapy anticoagulant therapy, and fibrinolytic therapy
- Anemia- classification, etiology, laboratory investigations, and management
- Hemoglobinopathies - sickle cell anemia, methemoglobinemia, thalassemia syndromes
- RBC membrane, metabolism, inherited defects in RBC membrane, and enzymes
- ABO blood group system – the biochemical basis of incompatibility and transfusion biology
- Plasma cell disorders

- Other disorders of hematopoietic cells and their progenitors.

### **Endocrine system:**

- Classification and general mechanism of action of hormones
- Biosynthesis, secretion, regulation, transport, and mode of action of hypothalamic peptides, adenohipophyseal and neurohypophyseal hormones, thyroid and parathyroid hormones, calcitonin, pancreatic hormones, adrenocortical and medullary hormones, gonadal hormones, gastrointestinal hormones, opioid peptides, parahormones
- Neuro-modulators and their mechanism of action and physiological significance
- Biochemical aspects of diagnosis and treatment of endocrinal disorders
- Endocrinology of conception, reproduction, and contraception
- Antenatal testing, newborn screening, and inborn errors of metabolism.

### **Cardiovascular system:**

- Atherosclerosis - pathogenesis, risk factors, prevention and treatment
- Biochemistry of cardiac failure, acute coronary syndrome, cardiomyopathies, and cardiac arrhythmias
- Cardiac biomarkers.

### **Respiratory system:**

- Pulmonary gaseous exchanges in health and disease
- Biochemistry of respiratory disorders.

### **Renal system:**

- Biochemistry of kidney functions
- Pathophysiology, biochemistry, laboratory findings and management in acute and chronic kidney diseases
- Nephrolithiasis, biochemical aspects of renal stones
- Biochemistry of renal transplant.

**Gastrointestinal system:**

- Biochemistry of gastric functions
- Regulatory peptides in the gut
- Digestion and absorption of nutrients, evaluation of malabsorption
- Biochemical aspects of- Peptic ulcer diseases, Zollinger-Ellison syndrome, Celiac disease, Inflammatory bowel disease, Protein losing enteropathy and Neuroendocrine tumors.

**Hepato-biliary and pancreatic system:**

- Biochemistry of hepato-biliary and pancreatic functions
- Formation, composition and functions of bile
- Pathophysiology, biochemistry, laboratory findings and management in acute and chronic hepato- biliary and pancreatic disorders.

**Skeletal system:**

- Bone structure, metabolism, associated disorders and markers
- Bone mineral homeostasis.

**Nervous system:**

- Neurotransmitters and their receptors
- Ion channels and channelopathies
- Neurotrophic factors
- Infective and inflammatory diseases of nervous system (meningitis, encephalitis etc.)
- Protein aggregation, neurodegeneration and related disorders (Alzheimer's disease, Parkinson's disease, Huntington's disease, and others)
- Prions and prion diseases
- Ischemic and hemorrhagic neuro disorders
- Neuro-immune disorders (Guillain-Barre syndrome, Myasthenia gravis, multiple sclerosis and others)
- Pathophysiology and biochemistry of psychiatric disorders
- Recent advances in Biochemistry.***

## **B. Psychomotor Domain**

The course contents are mentioned under Subject/domain-specific competencies.

### **MAPPING OF PROGRAMME OUTCOMES [POs] AND COURSE OUTCOMES [COs] OF PG PROGRAMMES**

<b>No.</b>	<b>By the end of the programme, the Postgraduate will have /be:</b>
PO 1	Knowledge and Skills
PO 2	Planning and problem solving abilities
PO 3	Communication
PO 4	Research Aptitude
PO 5	Professionalism and Ethics
PO 6	Leadership
PO 7	Societal Responsibilities
PO 8	Environment and Sustainability
PO 9	Lifelong Learner

## BIOCHEMISTRY

<b>Course Code</b>	<b>Course Title</b>
01200301	MD Biochemistry

### PROGRAMME OUTCOMES

<b>CO No.</b>	<b>At the end of the course, the learner should be able to:</b>	<b>Mapped Programme Outcomes</b>
CO 1	Explain concepts and principles of biochemistry and cell biology, including correlations of these with cellular and molecular processes involved in health , in disease states for clinical problem solving and research.	PO1,PO2,PO3, PO5, PO6,PO9
CO 2	Describe pathways of the intermediary metabolism along with their individual and integrated regulation and apply that in understanding the functioning of the body.	PO1,PO5, PO9
CO 3	Describe and apply the concept of nutrition in health and disease, micro- and macronutrition and essential nutrients, and interlinks of nutrients with metabolism and functions of a living system.	PO1,PO2,PO3, PO5, PO6, PO7,PO9
CO 4	Acquire knowledge on application of various aspects of genetic engineering in Medicine.	PO1,PO2,PO3, PO4, PO5, PO8,PO9
CO 5	Acquire knowledge and apply the principle of statistics, biostatistics and epidemiology to the evaluation and interpretation of molecular and metabolic disease states.	PO1,PO2,PO3, PO4, PO5, PO6, PO7,PO9
CO 6	Evaluate, analyze and monitor disease states by applying relevant biochemical investigations and interpreting the clinical and laboratory data and integrate principles of immunology in PCO3chemistry.	PO1,PO2,PO3, PO4, PO5, PO6, PO7,PO9



<b>CO No.</b>	<b>At the end of the course, the learner should be able to:</b>	<b>Mapped Programme Outcomes</b>
CO 7	Demonstrate knowledge of basics of research methodology, develop a research protocol, analyse data using currently available statistical software, interpret results and disseminate these results, to pursue further specializations and eventually be competent to guide students.	PO1,PO3,PO4, PO5, PO6, PO7,PO9
CO 8	Describe the principles of teaching – learning technology towards application. Take interactive classroom lectures, prepare modules organize and conduct PBLs, case discussions, small group discussions, Seminars, Journal club and research presentations	PO1,PO3,PO5, PO6,PO9
CO 9	Demonstrate knowledge about recent advances and trends in research in the field of clinical biochemistry.	PO1,PO2,PO3, PO4,PO5, PO7,PO9
CO 10	Communicate biochemical reasoning effectively to the members of the health care team and demonstrate empathy and respect towards patients, families, peers, and other healthcare professionals. regardless of the biochemical nature of their disease.	PO1,PO2,PO3, PO5, PO6,PO7 ,PO9
CO 11	Develop differential diagnoses for molecular and metabolic causes of diseases, suggest preventive, curative, and/or palliative strategies for the management of disease and Predict effectiveness and adverse effects associated with disease intervention.	PO1, PO2 PO3,PO5, PO6,PO7,PO9
CO 12	Demonstrate skills for clinical diagnosis, testing, understanding of biochemical conditions and diagnostic service.	PO1, PO2 PO3,PO4,PO5, PO6, PO9

