



SHRI  
DHARMASTHALA  
MANJUNATHESHWARA  
UNIVERSITY

Ordinance Governing  
MD BIOCHEMISTRY  
Curriculum 2019-20

**SHRI DHARMASTHALA MANJUNATHESHWARA UNIVERSITY**

(A State Private University established under the Shri Dharmasthala Manjunatheshwara University  
Act No 19 of 2018 of Government of Karnataka and Notification No. ED 261 URC 2018 dated 19th December 2018)

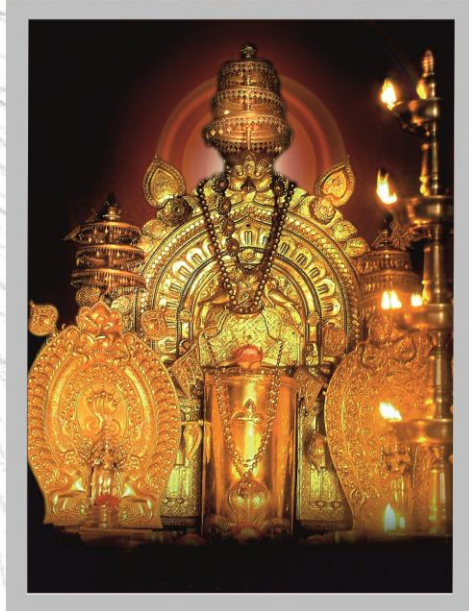
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|| Om Shri Manjunathaya Namaha ||



Shree Kshethra Dharmasthala

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## THE LOGO

Poojya Dr D. Veerendra Heggade, Hon'ble Chancellor of the University, while searching for an appropriate Logo for the University, saw a photograph picked from Temple Architecture showing Wings of a Bird, sculpted in Indian style and wanted it to be incorporated in the logo for the University, as the Wings symbolize 'Spreading of Knowledge beyond Boundaries'. Further it was felt that the Central theme of the logo should be 'Rudra' (The Linga) with three wings on each side. In this way, the logo of the University was conceptualized.

Hence:

1. The central part represents **Rudra** who Demolishes Darkness.
2. The Three **horizontal lines on The Linga** stand for Samyak Darshan (Right Belief), Samyak Gyan (Right Knowledge) and Samyak Charitra (Right Conduct).
3. The **Wings** symbolize spreading of Knowledge across the boundaries.
4. Base line "**Truth Liberates**" highlights the Purpose of Education: to liberate oneself unconditionally. It shows that it is not discipline, nor knowledge nor the efforts to freedom that liberate but Truth is what liberates you from all your conditioning and ignorance.

The overall significance of Shri Dharmasthala Manjunatheshwara University's Logo is:

**Darkness of ignorance is destroyed by the flow of knowledge to bring Liberty to everyone, by realizing the truth. And, it should spread globally without the boundaries as hindrance.**



SHRI  
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## VISION

Shri Dharmasthala Manjunatheshwara University will set the highest standards of teaching and learning by awakening the intelligence of the students and nurturing the creativity hidden in them by creating an environment where the ancient wisdom blends with modern science, to transform them into whole human beings to face the challenges.

## MISSION

- ▶ To ensure that the journey of education is inspiring, pleasant and enjoyable.
- ▶ Attract the best of teachers and students.
- ▶ Achieve high principles of trust, love and spirituality in the students.
- ▶ Create a collaborative, diverse and exclusive community.
- ▶ Transform the student of today to be a leader of tomorrow and a better human being.
- ▶ Produce passionate teachers.
- ▶ Evolve innovative teaching techniques.
- ▶ Create a peaceful environment.
- ▶ Prepare the student to face the social challenges.
- ▶ Create a University of which the Nation is proud of.
- ▶ Be an effective partner in Nation Building.
- ▶ Create an Eco-friendly University.
- ▶ Create a University based on the principles of beauty, love and justice.

||Om Shanti! Om Shanti! Om Shanti||



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SDMU/ACAD/MED/UG/367/2019

Date: 27-08-2019

## NOTIFICATION

### Ordinance governing Curricula of Pre-clinical Subjects in MBBS - 2019

- Ref:**
1. Notification from Board of Governors in Supersession of MCI (Letter No: MCI-Academics/2019/128106; Dated:06-07-2019)
  2. Medical Council of India Regulations on Graduate Medical Education, 1997 and its Subsequent Amendments
  3. Minutes of the 1<sup>st</sup> Meeting of Standing Committee of Academic Council held on 21-08-2019 (Letter No: SDMU/SCAC/362/2019; Dated:23-08-2019)
  4. Minutes of the 1<sup>st</sup> Meeting of Academic Council held on 20<sup>th</sup> March 2019 (Letter No: SDMU/AC/M-01/093/2019; Dated:21-03-2019)
  5. Minutes of the 1<sup>st</sup> Meeting of Joint Faculties held on 19<sup>th</sup> March 2019 (Letter No: SDMU/JF/85/2019; Dated:21-03-2019)
  6. Minutes of the 1<sup>st</sup> Meeting of Board of Studies held on 13<sup>th</sup> March 2019 (Letter No: SDMU/BOS Preclinical Medical (UG)/01/2019; Dated:15-03-2019)

In exercise of the powers conferred under Statutes 1.4(Powers and functions - Para ix & x), 1.5b(Powers and functions - Para b & c) and 1.8(Powers and functions - Para i) of Shri Dharmasthala Manjunatheshwara University, the Standing Committee of Academic Council is pleased to notify the ordinance governing the Curricula of Pre-clinical Subjects in MBBS - 2019 as shown in the annexure appended herewith:

1. Anatomy
2. Biochemistry
3. Physiology

The ordinance shall be effective for the students joining the course during 2019-20 and onwards.

  
**REGISTRAR  
REGISTRAR,  
Shri Dharmasthala Manjunatheshwara  
University, Dharwad**

## **CURRICULUM FOR COMPETENCY BASED POSTGRADUATE TRAINING FOR**

### **M. D - BIOCHEMISTRY**

#### **I. Goal**

The purpose of PG education is to create specialists who would provide high quality health care and advance the cause of science through research & training.

The post graduate course M.D. Biochemistry should enable the student to acquire an in depth knowledge of the fundamental principles of the subject of Biochemistry, so that he/she can apply this knowledge for understanding the basis of health and disease.

The student who has obtained MD degree in Biochemistry should be well-versed in basic concepts and recent advances in the subject and should have acquired skills and expertise in various laboratory techniques applicable to metabolic and molecular aspects of medicine and in research methodology. Training during the course should equip the student with skills to become an effective teacher, able to plan and implement teaching programmes for students in medical and allied health science courses, set up/manage a diagnostic laboratory, generate, evaluate and interpret diagnostic laboratory data, interact with clinicians to contribute to more effective patient care and carry out a research project and publish its results.

## **II. SPECIFIC LEARNING OBJECTIVES**

At the end of the MD training programme in Biochemistry, the post graduate student should have acquired competencies in the following areas, as detailed below.

### **1. Acquisition of knowledge**

The student should be able to explain clearly concepts and principles of biochemistry and cell biology, including correlations of these with cellular and molecular processes involved in health and disease.

### **2. Teaching and training**

The student should be able to effectively teach undergraduate students in medicine and allied health science courses so they become competent health care professionals and able to contribute to training of postgraduate students.

### **3. Diagnostic services**

The student should be able to set up/supervise/manage a diagnostic laboratory in Biochemistry in a hospital, ensuring quality control, and providing a reliable support service. The student should be able to provide clinicians with consultation services for diagnostic tests in biochemistry and in interpretation of laboratory results.

### **4. Research**

The student should be able to carry out a research project from planning to publication and be able to pursue academic interests and continue life-long learning to become more experienced in all the above areas and to eventually be able to guide postgraduates in their thesis work.



### **III. SUBJECT SPECIFIC COMPETENCIES**

The student during the training programme should acquire the following competencies:

#### **A. Cognitive domain**

1. Describe and apply biochemical principles to explain the normal state, abnormal disease conditions and mechanism of action used in the perception, diagnosis and treatment of diseases.
2. Explain energy transactions in a living system, and describe importance of biomolecules in sustaining the life process.
3. Describe pathways of the intermediary metabolism along with their individual and integrated regulation and apply that in understanding the functioning of the body.
4. Describe and apply the concept of nutrition in health and disease, micro- and macro- nutrition and essential nutrients, and interlinks of nutrients with metabolism and functions of a living system.
5. Apply and integrate knowledge of molecular and metabolic conditions in normal and disease states for clinical problem solving and research
6. Acquire knowledge on application of various aspects of genetic engineering in medicine.
7. Acquire knowledge and apply the principle of statistics, biostatistics and epidemiology to the evaluation and interpretation of molecular and metabolic disease states.
8. Evaluate, analyse and monitor disease states by applying relevant biochemical investigations and interpreting the clinical and laboratory data.
9. Able to integrate principles of immunology in biochemistry.

10. Demonstrate knowledge of basics of research methodology, develop a research protocol, analyse data using currently available statistical software, interpret results and disseminate these results and to have the potential ability to pursue further specializations and eventually be competent to guide students.
11. Describe the principles of teaching - learning technology towards application and take interactive classroom lectures, prepare modules for PBL, organize and conduct PBLs, case discussions, small group discussions, Seminars, Journal club and research presentations
12. Demonstrate knowledge of principles of Instrumentation.
13. Demonstrate knowledge about recent advances and trends in research in the field of clinical biochemistry.

## **B. Affective domain**

1. Effectively explain to patients from a variety of backgrounds, the molecular and metabolic basis of disease states and lifestyle modifications.
1. Communicate biochemical reasoning effectively with peers, staff and faculty, and other members of the health care team.
2. Demonstrate empathy and respect towards patients regardless of the biochemical nature of their disease.
3. Demonstrate respect in interactions with patients, families, peers, and other healthcare professionals.
4. Demonstrate ethical behaviour and integrity in one's work.
5. Demonstrate effective use of nutrition, lifestyle and genetic counselling.
6. Be aware of the cost of diagnostic tests and economic status of patients.
7. Acquire skills for self-directed learning to keep up with developments in the field and to continuously build to improve on skills and expertise.

### **C. Psychomotor domain**

1. Able to select, justify, and interpret the results of clinical tests in biochemistry.
2. Develop differential diagnoses for molecular and metabolic causes of diseases.
3. Suggest preventive, curative, and/or palliative strategies for the management of disease.
4. Predict effectiveness and adverse effects associated with disease intervention.
5. Demonstrate skills for clinical diagnosis, testing, understanding of biochemical conditions and diagnostic service.
6. Perform important biochemical, immunological and molecular biology techniques.
7. Observed working of important advanced techniques.
8. Demonstrate standard operating procedures of various methods and techniques used in clinical biochemistry.
9. Determination of enzyme activity and study of enzyme kinetics. Ideally it should be accompanied by purification (partial) of the enzyme from a crude homogenate to emphasise the concepts of specific activity, yield and fold purification.
10. Demonstrate and report routine investigations in haematology and microbiology.
11. Demonstrate presentation skills at academic meetings and publications.

**By the end of the course, the post graduate student should have acquired practical skills in the following:**

- a. Performance of reactions of carbohydrates, amino acids and proteins, and lipids.

- b. Experiments to demonstrate constituents of milk.
- c. Experiments to demonstrate normal and abnormal constituents of urine.
- d. Determination of iodine number and saponification number of fats.
- e. Estimation of ammonia and amino acids by Sorenson formal titration.
- f. Estimation of nitrogen estimation in a given amino acid solution by micro Kjeldahl method.
- g. Estimation of phosphorus by Fiske Subbarao method.
- h. Estimation of ascorbic acid in lime.
- i. Estimation of calcium content in milk.
- j. Estimation of proteins by Folin's method and dye binding method.
- k. Two-dimensional paper chromatography for separation of amino acids.
- l. Preparation and estimation of starch, glycogen, cholesterol, casein (phosphorus in casein) and haemoglobin from biological samples.
- m. Determination of Enzyme activity and study of enzyme kinetics, using any 2 suitable enzymes (e.g., catalase from rat liver and acid phosphatase from potatoes).
- n. Estimation of clinical analytes as detailed below:**
  - i. Diabetic profile - Blood glucose, glycated haemoglobin; performance of glucose tolerance test, electrolytes, Urine micro albumin Lipid profile - Cholesterol, Triglycerides, LDL, HDL.
  - ii. Renal function tests - Urea, Creatinine, Uric acid, Clearance tests, eGFR.
  - iii. Arterial blood gas analysis, Ionised Calcium.
  - iv. Ammonia, Lactate.
  - v. Liver function tests (bilirubin, serum proteins/albumin, hepato-biliary enzymes such as AST, ALT, ALP, GGT and prothrombin time).

- vi. Calcium, Magnesium, Copper (and ceruloplasmin), Serum iron, TIBC and Ferritin
- vii. Markers of myocardial damage – Total CK, CK MB, Troponins, LDH).
- viii. Other enzymes of diagnostic relevance (eg. phosphatases, amylase, Lipase etc).
- ix. Vitamins D, B12 and folate.
- x. Free fatty acids, phospholipids, Lp (a) .
- o. Thyroid function tests and other hormone assays by Chemiluminescence/ECLIA/ELISA/RIA.
- p. CSF analysis, urine analysis.
- q. Preparation of buffers.
- r. Electrophoresis of serum proteins, Hemoglobin electrophoresis.
- s. Electrophoresis of lipoprotein.
- t. Electrophoretic separation of LDH isozymes or any other isoenzymes.

### ***Clinical Laboratory***

- a. Taking any one parameter, students should prepare a Levy Jennings chart and plot inter-assay and intra-assay variation for the laboratory.
- b. Implementation of Westgard rules.
- c. Determination of reference values for any one parameter for the clinical laboratory (methodology).

***In addition, all efforts should be made to ensure that students at least see a demonstration of the following techniques.***

- a. Separation of peripheral blood lymphocytes using Ficoll Hypaque.
- b. Subcellular fractionation/marker enzymes for organelles to demonstrate fractionation.
- c. Ultracentrifugation.

- d. Isolation of high molecular weight DNA from tissues/blood.
- e. Isolation of RNA; synthesis of cDNA by reverse transcription; PCR (both conventional and real-time).
- f. Isolation of plasmids and agarose gel electrophoresis for proteins and nucleic acids
- g. Basic techniques in cell culture.
- h. High performance liquid chromatography (HPLC).

#### IV. SYLLABUS

**The course contents are outlined below:**

##### **PAPER I**

**Biomolecules, Cell biology, Biochemical techniques, Biostatistics and Research methodology, Basics of medical education in teaching and assessment of biochemistry.**

***Biomolecules:*** Properties of water, surface tension, osmosis, diffusion, viscosity, covalent and non-covalent interactions, atomic weight, molecular weight, Principles of thermodynamics, Donnan membrane equilibrium.

Concept of an acid, a base, pH, pK, buffer and buffering capacity, Henderson – Hasselbalch equation. Principles and procedures of determination of pH, pO<sub>2</sub>, pCO<sub>2</sub>, (blood gas analysis).

##### **A. Classification, structure and functions of amino acids and peptides**

- a) Biological importance of amino acids, amines, peptides and proteins.
- b) Structural organization of proteins and relationship with their functions - Primary, secondary, tertiary and quaternary structure of proteins.
- c) Protein folding and denaturation.

- d) Structure-function relationship of proteins.
- e) Structure and functions of haemoglobin and myoglobin.
- f) Structure and function of collagen.
- g) Structure and function of immunoglobulins.

## **B. Classification, functions, properties and reactions of carbohydrates**

- a) Biological importance of carbohydrates.
- b) Chemistry, structure and properties of monosaccharides, disaccharides and polysaccharides. Structure of functions of heteropolysaccharides.

## **C. Classification, properties and importance of lipids**

- a) Biological importance of lipids.
- b) Fatty acids - nomenclature, classification, properties, reactions.
- c) Mono, di- and triacylglycerols.
- d) Trans fats.
- e) Cholesterol - structure, properties and functions.
- f) Phospholipids - definition, types, properties and importance.
- g) Glycolipids - definition, types, functions, examples.
- h) Lipoproteins - definition, structure, types, functions.
- i) Role of apoproteins, importance in health and disease.
- j) Biological membranes - structure, function, properties and importance.
- k) Micelles and Liposomes.

## **D. Nucleotides and nucleic acids**

- a) purine and pyrimidine bases in DNA and RNA.
- b) Nucleosides and nucleotides.
- c) Physiologically important nucleotides.

- d) Synthetic analogues of purine/pyrimidine bases and nucleosides used as therapeutic agents (anti-cancer drugs, anti-viral drugs).
- e) Watson and Crick model of DNA structure.
- f) Structure and functions of different types of RNA.

### **E. Cell biology**

- a) Cell cycle, mitosis, meiosis and mechanisms of cell death.
- b) Structure of the cell and different subcellular organelles.
- c) Cytoskeleton, muscle contraction and cell motility.
- d) Structure and functions of cell membrane, solute transport across biological membranes.
- e) Intracellular traffic and sorting of proteins.
- f) Intracellular signalling pathways, membrane receptors and second messengers.
- g) Extracellular matrix: composition, importance and biomedical importance, cellular adhesion molecules and intercellular communication.
- h) Red and white blood cells.

### **F. Analytical techniques in biochemistry**

- a) Colorimetry and Spectrophotometry (UV and visible spectrophotometry).
- b) Atomic absorption spectrophotometry.
- c) Flame photometry.
- d) Fluorometry.
- e) Turbidimetry and nephelometry.
- f) Gravimetry.
- g) Electrochemistry (pH electrodes, ion-selective electrodes, gas-sensing electrodes).



- h) Automated analysers: Semi Auto Analyzer, Auto Analyzer.
- i) Chemiluminescence.
- j) Water testing.
- k) Electrophoresis - principle, types, applications; isoelectric focusing capillary electrophoresis; 2-D electrophoresis.
- l) Chromatography - principle, types including high performance liquid chromatography and gas chromatography.
- m) Techniques in molecular biology: Blotting techniques, polymerase chain reaction (PCR), DNA and protein sequencing, microarrays and DNA chip technology, cloning techniques, genomics, proteomics and metabolomics.
- n) Ultracentrifugation techniques: their applications in the study of lipoproteins.
- o) Cell fractionation: isolation and purification of sub cellular particles, biochemical markers of different subcellular organelles.
- p) Protein extraction, purification and quantification techniques.
- q) Cytogenetics – Karyotyping, FISH, centromeric probes, chromosome painting probes etc.
- r) Cell culture techniques.
- s) Microscopy – light, electron, fluorescent.
- t) Mass spectrometry.
- u) Flow cytometry.
- v) Techniques to study in vivo metabolism - NMR, SPECT, PET scans, etc.
- w) Radioisotope-based techniques and its applications.
- x) Nanotechnology and microfabrication - Basics, application in medicine and research.

## **G. Biostatistics and Research methodology**

### **▪ Biostatistics:**

- a) Basic concepts of biostatistics as applied to health science.
- b) Statistical tests: t-test, analysis of variance, chi-square test, non-parametric tests, correlation and regression.
- c) Statistical methods of validation of diagnostic tests.

### **▪ Research methodology**

- a) Research question, Hypothesis, Objectives, Methodology.
- b) Literature search for research question.
- c) Basics of epidemiological study designs and sampling methodologies.
- d) Qualitative and Quantitative research.
- e) How to write a research paper and review.
- f) Dissertation writing.
- g) Grant writing.
- h) Ethics in research.
- i) Intellectual property rights.

## **H. Basics of medical education in teaching and assessment of Biochemistry**

Principles of adult learning, taxonomy of learning, educational objectives, principles of assessment and question paper setting, methods of assessing knowledge, appropriate use of media, microteaching, small group teaching .

**Environmental Biochemistry: Health and pollution.**

## **Paper II:**

**Enzymes, Bioenergetics, Biological oxidation, Intermediary metabolism and regulation, Inborn errors of metabolism and Nutrition.**

### **A. Enzymes:**

Classification, Properties, classification, Active site, mechanism of action, coenzymes and cofactors, Kinetics of enzyme activity - Factors affecting enzyme catalyzed reactions, Michaelis-Menten constant, Lineweaver- Burk plot, Edee-Hofstee plot.

Enzyme inhibitions- competitive, non-competitive, uncompetitive and allosteric, mechanism and application. Enzyme poisons.

Methods of locating the functional groups of active sites. Mechanism of enzyme action in detail. Enzyme regulations. Mechanism of specific enzymes. Isoenzymes, diagnostic and therapeutic enzymes, principles of assays of enzymes, enzymes as therapeutic targets of drugs., Immobilized enzymes- application.

## **B. Biological oxidation**

Basic concepts of thermodynamics and its laws, as applied to living systems, Exergonic and endergonic reactions and coupled reactions, redox potential High energy compounds.

Classification and role of oxidoreductases

Cytochromes; cytochrome P450 system

## **C. Respiratory chain and oxidative phosphorylation**

- a) Components, complexes and functioning of the respiratory chain
- b) Process of oxidative phosphorylation
- c) Mechanisms of ATP synthesis and regulation
- d) Mitochondrial transport systems and shuttles
- e) Inhibitors, uncouplers and ionophores
- f) OXPHOS diseases

## **D. Overview of metabolism and intermediary metabolism**

### **Metabolism of carbohydrates**

- a) Digestion and absorption
- b) Glycolysis and TCA cycle, including regulation
- c) Glycogen metabolism and its regulation
- d) Cori cycle, gluconeogenesis and control of blood glucose
- e) Metabolism of fructose and galactose
- f) Pentose phosphate and uronic acid pathways and their significance
- g) Polyol pathway
- h) Regulation of blood glucose levels
- i) Diabetes mellitus (including gestational diabetes mellitus) – classification, pathogenesis, metabolic abnormalities, diagnostic criteria, principles of treatment, pathogenesis of complications, laboratory tests
- j) Metabolism of ethanol

## **E. Metabolism of lipids**

- a) Digestion and absorption, including role of bile salts
- b) Biosynthesis and oxidation of fatty acids
- c) Ketone bodies – formation, utilisation and regulation
- d) Metabolism of unsaturated fatty acids and eicosanoids
- e) Metabolism of triacylglycerol; storage and mobilisation of fats
- f) Metabolism of cholesterol
- g) Metabolism of lipoproteins
- h) Metabolism in adipose tissue
- i) Role of liver in lipid metabolism
- j) Role of lipids in atherogenesis
- k) Metabolism of phospholipids, sphingolipids and associated disorders

## **F. Metabolism of amino acids and proteins**

- a) Digestion and absorption
- b) Pathways of amino acid degradation - transamination, oxidative deamination
- c) Transport and metabolism of ammonia
- d) Metabolism of individual amino acids.
- e) Plasma proteins

## **G. Metabolism of nucleotides**

- a) De novo synthesis of purine nucleotides
- b) Salvage pathway for purines
- c) Degradation of purines
- d) De novo synthesis of pyrimidine nucleotides
- e) Degradation of pyrimidine
- f) Synthetic analogues of purine/pyrimidine bases and nucleosides used as therapeutic agents

## **H. Metabolism of heme**

- a) Biosynthesis of heme and associated disorders
- b) Degradation of heme and associated disorders

## **I. Metabolism in individual tissues and in the fed and fasting states**

- a) Liver, adipose tissue, brain, RBCs

## **J. Nutrition**

- a) Principal food components
- b) General nutritional requirements
- c) Energy requirements

- d) Biological value of proteins
- e) Thermogenic effect of food
- f) Balanced diet, diet formulations in health and disease, mixed diet
- g) Nutritional supplements
- h) Food toxins and additives
- i) Parenteral nutrition
- j) Disorders of nutrition, protein and protein energy malnutrition, dietary fibers, under-nutrition, laboratory diagnosis of nutritional disorders
- k) Obesity – Risk factors, metabolic derangements, genetics, hormonal regulation of adipose tissue metabolism, hormonal regulation of eating behavior, adipokines
- l) National Nutrition Programme.

#### **K. Vitamins**

Classification, biochemical role, sources, RDA and deficiency state of each vitamin (including diagnostic tests for deficiency and treatment)

#### **L. Minerals**

Classification, biochemical role, sources, requirement and deficiency state of each mineral (including diagnostic tests for deficiency and treatment)

#### **M. Metabolism of Xenobiotics**

Free radicals and anti-oxidant defence systems in the body and associations with disease processes

### **Paper III:**

Molecular biology, molecular and genetic aspects of cancer, immunology and effects of environmental pollutants on the body.

Structure and organization of chromosomes and chromatin re-modelling

#### **A. DNA replication**

- a) DNA replication in prokaryotes and eukaryotes (including important differences between the two): Roles of DNA polymerase, helicase, primase, topoisomerase and DNA ligase, Replication fork, Okazaki fragments and its importance in replication.
- b) Overview of role of major DNA repair mechanisms – mismatch repair, base excision repair, nucleotide excision repair and double strand break repair, Diseases associated with abnormalities of DNA repair systems
- c) DNA recombination

#### **B. Transcription**

- a) Structure of a gene - exons and introns, promoter, enhancers/repressors and response elements.
- b) Process of transcription in prokaryotes and eukaryotes – initiation, elongation and termination (including important differences).
- c) Post-transcriptional processing – capping, tailing and splicing.

#### **C. Genetic code and mutations**

- a) Characteristics of the genetic code.
- b) Molecular basis of degeneracy of the genetic code (Wobble hypothesis).
- c) Mutagens- examples of physical, chemical and biological mutagens.
- d) Types of mutations – point mutations and chromosomal mutations.
- e) Relationship of mutations with specific diseases.

#### **D. Translation**

- a) Basic structure of prokaryotic and eukaryotic ribosomes.
- b) Structure of tRNA (diagram of clover leaf model of tRNA structure) and its function in protein synthesis.
- c) Function of aminoacyl tRNA synthase.
- d) Process of protein synthesis (translation) – initiation, elongation and termination (including important differences between prokaryotic and eukaryotic translation).
- e) Inhibition of prokaryotic translation by antibiotics.
- f) Post-translational modification.

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

- a) The operon concept in prokaryotes.
- b) Role of general and gene specific transcription factors.
- c) Small interference RNA (siRNA) and micro RNA (miRNA).
- d) Other modes of regulation of gene expression: alternative splicing, alternative promoter usage, DNA methylation, Histone acetylation / deacetylation, RNA editing, alterations of RNA stability.

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

- a) Concepts of recombinant DNA technology, genetic engineering, biotechnology and cloning.
- b) Restriction endonucleases.
- c) Vectors for cloning – plasmids and phages.
- d) Genomic and cDNA libraries.
- e) Applications of recombinant DNA technology in medicine.
- f) Gene therapy.



- g) Diagnosis of genetic diseases and genetic counselling.
- h) DNA fingerprinting.
- i) DNA sequencing.
- j) Microarrays.
- k) Fluorescent in situ hybridization (FISH).
- l) DNA vaccines.
- m) Transgenic animals.
- n) Application of molecular techniques in forensic investigation and medico-legal cases.

## **G. Overview of Human Genome Project**

Bioinformatics and Computational biology – Basics, application in medicine and research, Principles of human genetics

- a) Alleles, genotypes and phenotypes.
- b) Patterns of inheritance: monogenic and polygenic inheritance.
- c) Population genetics.
- d) Genetic factors in causation of diseases.
- e) Types of genetic diseases: Chromosomal, monogenic and polygenic disorders, mitochondrial disorders, nucleotide repeat expansion disorders, imprinting disorders.
- f) Screening for genetic diseases and prenatal testing.
- g) Ethical and legal issues related to medical genetics.

## **H. Stem cells in clinical medicine**

- a) Basic concepts regarding stem cells.
- b) Types of stem cells: embryonic and induced pluripotent stem cells (iPSC).
- c) Potential applications in the clinical medicine.
- d) Ethical and legal issues related to use of stem cells in medicine.

## **I. Cancer**

- a) Carcinogens: physical, chemical and biological.
- b) Clonal origin of cancers.
- c) Genetic basis of carcinogenesis.
- d) Role of oncogenes and tumour suppressor genes.
- e) Familial cancer syndromes.
- f) Cancer stem cells.
- g) Epigenetic regulation in cancer.
- h) Gene expression profiling in cancer.
- i) Cancer cell biology: cell cycle abnormalities, telomerase activity, proliferative capacity and decreased apoptosis.
- j) Metastasis.
- k) Tumor markers.
- l) Biochemical basis of cancer chemotherapy and drug resistance.
- a) New methods of anti-cancer therapy: targeted cancer therapy, cancer immunotherapy.

## **J. Immunology**

- a) Innate and acquired immunity.
- b) Humoral and cell-mediated immunity.
- c) Cells and organs of the immune system - T and B cells, macrophages, dendritic cells, NK cells, granulocytes.

- d) Antigens, epitopes and haptens.
- e) Immunoglobulin classes, isotypes, allotypes, idiotypes, monoclonal antibodies, organization and expression of immunoglobulin genes, immunoglobulin gene rearrangement, class switching.
- f) Antigen-antibody interaction - immunochemical techniques.
- g) Major histocompatibility complex, antigen processing and presentation.
- h) T cell and B cell receptor, toll like receptors.
- i) T cell maturation/activation/differentiation.
- j) B cell generation/activation/differentiation.
- k) Cytokines.
- l) Complement system, cell.
- m) Immune response to infections.
- n) Hypersensitivity reactions.
- o) Vaccines.
- p) Immuno-deficiency syndromes.
- q) Autoimmunity.
- r) Transplantation immunology.
- s) Cancer and immune system.
- t) Immunodiagnostics.
- u) Immunotherapy.

#### **Paper IV:**

Clinical Biochemistry and Molecular diagnostics related to different body systems/ organs, Endocrinology, and Recent advances in Biochemistry.

#### **A. Basic principles and practice of Clinical Biochemistry:**

Units of measure, reagents, clinical laboratory supplies, basic separation techniques, laboratory calculations, specimen collection and

processing, safety in the laboratory, clinical utility of laboratory tests (including sensitivity, specificity, ROC curves, etc), analysis in the laboratory, selection and evaluation of methods (including statistical techniques), evidence-based laboratory medicine, establishment and use of reference values, pre-analytical variables and biological variations, quality management, clinical laboratory informatics.

### **B. Analytical techniques and Instrumentation:**

Principles of basic techniques used in a clinical biochemistry laboratory (spectrophotometry, electrochemistry, electrophoresis, osmometry, chromatography, mass spectrometry, immunochemical techniques, molecular techniques, automation, point of care testing.

### **C. Clinical correlates and analytical procedures:**

- a) Amino acids, peptides and proteins; non-protein nitrogenous compounds.
- b) Enzymes
- c) Carbohydrates
- d) Lipids, lipoproteins and apolipoproteins and other cardiovascular risk factors
- e) Electrolytes
- f) Blood gases and pH
- g) Hormones and associated disorders
- h) Catecholamines and serotonin
- i) Vitamins; trace and toxic elements
- j) Hemoglobin, and bilirubin
- k) Porphyrins and associated disorders
- l) Bone and mineral metabolism
- m) Tumour markers
- n) Assessment of organ functions (hypothalamus and pituitary, adrenal glands,

gonads, thyroid, parathyroid, liver, kidney, heart, stomach, pancreas, intestine, etc) and associated disorders

- o) Pregnancy and maternal and fetal health.
- p) Reproduction related disorders – infertility.
- q) Newborn screening
- r) Inborn errors of metabolism
- s) Hemostasis
- t) Therapeutic drug monitoring
- u) Clinical toxicology
- v) Molecular diagnostics
- w) Body fluid analyses

**D. Regulation of fluid and electrolyte balance and associated disorders, Regulation of acid-base balance and associated disorders, Biochemistry of the endocrine system.**

- a) Classification and general mechanism of action of hormones.
- b) Biosynthesis, secretion, regulation, transport and mode of action of hypothalamic peptides, adenohipophyseal and neurohipophyseal hormones, thyroid and parathyroid hormones, calcitonin, pancreatic hormones, adrenocortical and medullary hormones, gonadal hormones, gastrointestinal hormones, opioid peptides, parahormones.
- c) Biochemistry of conception, reproduction and contraception, Prenatal diagnosis, Infertility
- d) Endocrine interrelationship and their involvement in metabolic regulation.
- e) Neuro-modulators and their mechanism of action and physiological significance.
- f) Biochemical aspects of diagnosis and treatment of endocrinal disorders.

## **E. Hematopoietic disorders**

- a) Iron deficiency and other hypoproliferative anaemias - iron metabolism, laboratory tests of iron status, iron therapy.
- b) Anaemia of chronic disease, anaemia of renal disease
- c) Hemoglobinopathies - sickle cell anaemia, methaemoglobinemias, thalassemia syndromes, Megaloblastic anaemia.
- d) RBC membrane and metabolism
- e) Hemolytic anaemia - inherited defects in RBC membrane and enzymes (G6PD deficiency), immunologic causes of hemolysis
- f) ABO blood group system - biochemical basis, transfusion biology.
- g) Plasma cell disorders - multiple myeloma.

## **F. Hemostasis and thrombosis**

Biochemical mechanisms, the vessel wall, prostacyclins, nitric oxide, clotting factors, blood clotting, related laboratory tests, antiplatelet/ anticoagulant/ fibrinolytic therapy.

## **G. Cardiovascular system**

Atherosclerosis - pathogenesis, risk factors, prevention and treatment.

Cardiac failure, acute coronary syndrome, cardiac biomarkers.

Dyslipidemia and cardiovascular risk assessment, shock, Hypertension.

## **H. Respiratory system**

Gaseous exchange in lungs - physiological features and disturbances, arterial blood gases

Pathogenesis of cystic emphysema, alpha-1 anti-trypsin deficiency.

## **I. Kidney**

Kidney function tests; pathophysiology, biochemistry, laboratory findings and management in acute kidney injury and chronic kidney disease; estimation of GFR;

Glomerular diseases - pathogenesis and mechanisms of glomerular injury, nephrotic syndrome, diabetic nephropathy; tubular disorders - renal tubular acidosis, proteinuria, nephrolithiasis, kidney transplant; biochemical aspects of renal stones.

## **J. Gastrointestinal system**

- a) Gastric physiology.
- b) Pathophysiology of peptic ulcer disease, including role of *H. pylori*; gastric function tests; Zollinger-Ellison syndrome.
- c) Digestion and absorption of nutrients; evaluation of malabsorption (steatorrhea, lactose intolerance).
- d) Celiac disease.
- e) Inflammatory bowel disease.
- f) Protein losing enteropathy.
- g) Regulatory peptides in the gut.
- h) Neuroendocrine tumours.

## **K. Liver**

- a) Liver function tests.
- b) Hyperbilirubinemias.
- c) Viral hepatitis
- d) Serologic/virologic markers.
- e) Alcoholic liver disease, fatty liver, chronic liver disease, cirrhosis and its complications.

- f) Pathogenesis of ascites.
- g) Hepatic encephalopathy.
- h) Metabolic diseases affecting liver
- i) Reye's syndrome.
- j) Diseases of gall bladder/bile ducts - pathogenesis of gallstones.
- k) Pancreas - acute and chronic pancreatitis, cystic fibrosis, pancreatic function tests.

#### **L. Bone and mineral metabolism**

Bone structure and metabolism; metabolism of calcium, phosphate and magnesium; regulation and abnormalities of bone metabolism; vitamin D; parathyroid hormone; calcitonin; parathyroid hormone-related (PTHrP); osteoporosis – pathophysiology; markers of bone turnover.

#### **M. Nervous system**

- a) Neurotransmitters and their receptors
- b) Ion channels and channelopathies
- c) Neurotrophic factors.
- d) Protein aggregation and neurodegeneration.
- e) Alzheimer's disease, Parkinson's disease, Huntington's disease, multiple sclerosis.
- f) Prions and prion disease.
- g) Guillain-Barre syndrome – immunopathogenesis.
- h) Myasthenia gravis – pathophysiology.
- i) Hereditary myopathies - Duchenne muscular dystrophy.
- j) Inherited disorders of muscle energy metabolism.
- k) Mitochondrial myopathies.
- l) Pathophysiology of psychiatric disorders such as anxiety, depression and schizophrenia.



## **N. Clinical Toxicology**

Pathological mechanisms and symptoms of most important types of toxic syndromes (anticholinergic, cholinergic, opioid, sedative, sympathomimetic), Pharmacology and analysis of specific drugs and toxins.

## **V. TEACHING AND LEARNING METHODS**

### **Teaching methodology**

Active and interactive learning should be the mainstay of the program. The following methods are to be used to facilitate learning by and training of MD students.

#### **1. Interactive lectures, tutorials, problem-based learning, case discussions, seminars, guest lectures, E-learning**

The above teaching learning methods should be employed for the post graduate students to acquire updated knowledge on various aspects of basic and clinical biochemistry, immunology and molecular biology, and their application in modern medicine and also to learn to communicate effectively.

*Each PG student should present a minimum of 8 seminars and 8 cases during their PG course. Seminar topics should cover from any of the following - Basic metabolism, cell biology, genetics, nutrition, organ functions, endocrinology, analytical techniques, immunology, clinical biochemistry, quality assurance, topic concerned to thesis work and recent advances.*

## **2. Journal club**

Journal club sessions should be used by post graduate students to learn to search medical literature, to learn how scientific data is to be disseminated, to develop skills in presentation of research papers, to critically analyse and evaluate data, to become familiar with research methodologies, to keep oneself updated on new developments/emerging trends in biochemistry and to learn to communicate effectively.

*Each PG student should present a minimum of 8 journal articles during their PG course. Articles reviewed and presented can include from any of the following – Case reports, Meta-analysis, Systematic reviews, Original articles related to comparative studies, longitudinal studies, mechanism based studies, analytical- method validation/sensitivity specificity studies, animal model based studies, RCTs and genetic studies.*

## **3. Practical exercises**

These exercises should be used by post graduate students to equip themselves with knowledge and hand-on skills in various techniques used for laboratory bench-work in Biochemistry and molecular biology and in a diagnostic laboratory, and to learn to analyze and interpret data obtained. Student should maintain practical record for general and clinical biochemistry of all practicals done during the course and submit at the time of university examination after duly certified by the Head of the Department.

## **4. Thesis**

Under the supervision of a Professor or Associate Professor in the Department of Biochemistry, each PG student is expected to generate a hypothesis/research question and design a research protocol to test/

answer it. The protocol should have clearly defined objectives and a work plan. The post graduate student will carry out the experimental research work proposed, analyse data, interpret results and write a thesis/ dissertation based on the work done and results obtained. Every student should submit dissertation on a selected research problem involving laboratory investigations. The dissertations have to be prepared by student and submitted to the university 6 months prior to the final examination as notified by the university.

#### **5. Presentation of work done on thesis to peers**

Post graduate should present the progress of work to his/her guide and peers regularly at least once in 3 months after acceptance of the study by university. Record of progress report duly signed by guide and HOD needs to be maintained by the postgraduate. A post graduate student of a postgraduate degree course in broad specialities/super specialities would be required to present one poster presentation, to read one paper at a national/state conference and to present one research paper which should be published/ accepted for publication/sent for publication during the period of his postgraduate studies so as to make him eligible to appear at the postgraduate degree examination.

#### **6. Teaching of undergraduates**

Postgraduate students in Biochemistry shall be required to participate in teaching and training programmes of undergraduate students. They should learn how to organize, conduct and co-ordinate UG laboratory teaching in practical classes, to participate in clinical case-based teaching sessions and small group discussions (as part of a team that includes faculty members

and senior residents of the department), to develop skills of self-directed learning, effective communication and leadership. They should learn how to work as part of a team and to facilitate learning by students.

#### **7. Horizontal and vertical integration of teaching of Biochemistry with other pre- clinical, Para-clinical and clinical departments**

The post graduate students should take part in integrated teaching of undergraduates by participation in joint teaching sessions and seminars with different departments, participation in clinical rounds for discussing cases of interest and by small group discussions of case-based problems.

#### **8. Training in the basics of medical education and technology**

The post graduate students may be provided with training in the basics of medical education and technology through workshops at the departmental and/or institutional level.

#### **9. Development of communication skills**

The post graduate students should develop effective communication skills by making presentations at seminars and journal club sessions and by teaching undergraduates.

#### **10. Training in clinical Biochemistry:**

The post graduate students should receive hands-on training in a diagnostic laboratory in Biochemistry; such training should be extensive and rigorous enough for each post graduate student to acquire adequate skills and expertise to manage and supervise such a laboratory. The post graduate students should be posted in all sections of the laboratory in

the institution, starting from sample collection and processing. They should become proficient in working with the auto analysers in the laboratory, in quality control methods, setting up of a clinical biochemistry laboratory, specialized assays and statistical analysis of data. It would also be desirable for them to acquire experience in running a 24-hours diagnostic laboratory; towards this end, it would help if they are posted in the laboratory out of regular hours as well.

### **11. Rotation in clinical departments**

It would be desirable for the post graduate students to be posted in clinical departments after their training period in the diagnostic laboratory, for up to 6 months of the course. These postings can be spread out in first 2 year of the PG course. 3<sup>rd</sup> year PG students need to be posted exclusively to clinical Biochemistry laboratory.

Clinical postings in the forenoon to be attended by PGs and return back to the department to do the experimental work in the afternoon.

Departments and durations of postings are as follows:

- a. General medicine (including ICU, Nephrology) – 1 month
- b. Endocrinology (including Reproductive endocrinology) – 15 days
- c. Pediatrics - 15 days
- d. Hematology, Clinical Pathology and blood bank- 1 month
- e. Routine Microbiology - 1 month
- f. \*Molecular Genetics, NGS, MS-MS – 10 days
- g. \*Cytogenetics, Flow cytometry – 10 days
- h. \*NABL accredited lab – 10 days

***\*Optional postings - Students may be posted to institution where these facilities are available if not available in host institution.***

These postings will help post graduate students get a better perspective on diagnostic tests in clinical practice and will enable them to contribute more effectively to patient care.

Other than the period of these clinical postings, every postgraduate student in Biochemistry shall be posted to clinical biochemistry laboratory of the department where clinical investigations of the attached hospital are done. Student should be trained in collection of samples, carrying out investigations, interpretation, reporting of the results and maintenance in records of investigations, Quality assurance.

### **Skills to be acquired during the postings**

During posting in medical and other related departments, the student should acquire relevant knowledge and skills. These generally include:

- a. Clinical examination of a patient.
- b. Investigations to be carried and their relevance.
- c. Drawing of blood, collection of urine and other specimens for investigations and their storage.
- d. Biopsy techniques and handling of biopsy material to be sent for relevant tests/ investigations.
- e. Interpretation of laboratory data, X ray and biopsy results.
- f. **Clinical pathology postings: (Hematology, transfusion serology, coagulation and cellular immunology)**
  - i. Determination of ESR, Hb, Hematocrit, cell count, MCV, MCH, MCHC.
  - ii. Preparation and staining of blood smears.
  - iii. Morphological investigation of bone marrow Smears, different staining procedures.
  - iv. Coagulation tests.

- v. Determination of coagulation factors.
- vi. Investigation of fibrinolysis.
- vii. Blood group-typing, Cross matching for transfusion.
- viii. Investigation of transfusion reactions.
- ix. Preparation and application of blood components.
- x. Immunohistochemistry.

**g. Microbiology: (Covering bacteriology, virology, parasitology and mycology)**

- i. Specimen collection.
- ii. Specimen processing: smears, staining, culture and sensitivity.
- iii. Serology tests.
- iv. Techniques for parasite and fungus identification.
- v. Immunological and molecular diagnosis (PCR) – HIV, Tuberculosis etc.

**12. Log Book:**

All post graduate students should maintain a log book that documents all the work that they have done during their years of training. This log book will be checked and assessed periodically by the faculty members involved in the training programme.

**13. Department will encourage e-learning activities.**

*Note-During the training programme, patient safety is of paramount importance, therefore skills are to be learnt initially on the models, later to be performed under supervision followed by performing independently; for this purpose, provision of skills laboratories in medical colleges is mandatory.*

## **VI. ASSESSMENT**

### **Formative assessment during the training**

#### **A. FORMATIVE ASSESSMENT, i.e., during the training**

##### **General Principles**

Internal Assessment should be frequent, cover all domains of learning and used to provide feedback to improve learning; it should also cover professionalism and communication skills. The Internal Assessment should be conducted in theory and practical/clinical examination.

##### **Quarterly assessment during the MD training should be based on:**

1. Journal based / recent advances learning
2. Patient based /Laboratory or Skill based learning
3. Self-directed learning and teaching
4. Departmental and interdepartmental learning activity
5. External and Outreach Activities / CMEs

The student to be assessed periodically as per categories listed in postgraduate student appraisal form (Annexure I).

6. **Periodic tests:** Three tests may conducted, two of them be annual tests, one at the end of first year and the other in the second year. The third test may be held three months before the final examination. The tests may include written papers, practicals / clinicals and viva voce.
7. **Records:** Records, log books and marks obtained in tests will be maintained by the Head of the Department and will be made available to the University or MCI.



## B. SUMMATIVE ASSESSMENT

### At the end of training

The summative examination will be carried out as per the Rules given in POSTGRADUATE **MEDICAL EDUCATION REGULATIONS, 2000.**

**Marks distribution shall be as follows:**

Subject	Theory	Practical	Viva-Voce	Total
Biochemistry	400	200	100	700

**The postgraduate examination shall be in three parts.**

### 1. Thesis

Every post graduate student shall carry out work on an assigned research project under the guidance of a recognized post-graduate teacher. The results of the work done shall be written up and submitted in the form of a thesis. The aim of doing a thesis is to contribute to development of a spirit of enquiry, to familiarize the post graduate students with research methodology, literature searches, laboratory techniques, analysis of data, interpretation of results and skills in scientific writing.

The thesis shall be submitted at least six months before the theory and clinical / practical examination. The thesis shall be examined by a minimum of three examiners; one internal and two external examiners, who shall not be the examiners for theory and clinical examinations. A post graduate student shall be allowed to appear for the theory and practical/clinical examination only after the acceptance of the thesis by the examiners. Thesis **could be accepted with corrections** if there is possibility to provide corrections within the next 2 months and submit. **If not accepted:** Candidate can take up theory exam after 6 months following submission of

corrected thesis subject to acceptance. The thesis evaluation report of the students to be sent to the college from the university before student pays fees for university theory exam.

## 2. Theory examination: 400 Marks

The examinations shall be organized on the basis of a 'Grading' or 'Marking' system to evaluate and certify a post graduate student's level of knowledge, skills and competence at the end of the training. Obtaining a minimum of 50% marks in 'Theory' and 'Practical' examinations separately shall be mandatory for passing the examination as a whole. The examination for MD/MS shall be held at the end of the 3rd academic year.

There shall be 4 theory papers of 100 marks each of three hours duration:

**Each paper shall have TEN short essay questions of 10 marks (10x10=100).**

The distribution of topics/chapters for the papers will be as under \*:

Paper	Syllabus
Paper I	Biomolecules, cell biology, biochemical techniques, biostatistics and research methodology, basics of medical education in teaching and assessment of biochemistry
Paper II	Enzymes, bioenergetics, biological oxidation, metabolism of biomolecules, intermediary metabolism and regulation, inborn errors of metabolism and nutrition
Paper III	Molecular biology, molecular and genetic aspects of cancer, immunology and effects of environmental pollutants on the body
Paper IV	Clinical biochemistry and molecular diagnostics related to different body systems/organs, endocrinology, and recent advances in biochemistry

**Note\*** the topics assigned to the different papers are given as general guidelines. A strict division of subjects may not be possible. Some overlapping of topics is inevitable. Students should be prepared to answer the overlapping topics.

### **3. Practical and oral/viva voce examination:**

#### **Practical Examination: 200 marks**

This should be held over two days.

#### **Practical examination**

The practical examinations will be held over 2 days; one day will be mainly for the practical exercises and the second day for the oral/ viva voce. The practical examinations will have the following components:-

#### **A. Clinical case with Estimations: 80 marks**

A clinical case for which an actual patient or a paper-based case may be used, as per the facilities available in each institution running the course. The clinical features of the patient and relevant laboratory investigation of biochemical abnormalities present will be discussed.

1. Case discussion – 30 marks.
2. Clinical Biochemistry (2 relevant biochemical investigations including estimation of one parameter using standard curve) – 50 marks (40 marks for one estimation using standard curve and 10 marks for one estimation using single standard).

#### **B. Chromatography: 40 marks**

Identification of the carbohydrate/amino acid provided by chemical tests and confirmation of its identity by paper chromatography / TLC chromatography, Urine analysis.

**C. Electrophoresis: 40 marks**

Performance of an electrophoresis for serum proteins and discussion of electrophoretic pattern.

**D. Quality Control, its interpretation and Method validation – 40 marks**

**Viva-voce Examination: 100 Marks**

**E. Thesis presentation: 20 marks**

(Of about 15 mins duration)

**F. Pedagogy Exercise: 20 marks (20 mins duration plus 10 mins for questions)**

A topic would be given to each candidate along with the practical examination question paper on the first day. Student is asked to make a presentation on the topic on the second day for 20 minutes.

**G. Subject Viva Voce: 60 marks**

Viva Voce examination will be conducted conjointly by all the examiners to test comprehension, analytical approach, expression and interpretation of facts. Students shall also be given case reports, charts for interpretation. It includes discussion on dissertation.

**VII. SUGGESTED READING MATERIAL:**

**Books (latest edition)**

1. Murray RK, Grannar DK, Mayes PA, Rodwell VW, Harper's Illustrated Biochemistry, McGraw – Hill
2. Champe PC, Harvey RA, Ferrier DR, Lippincotts Illustrated reviews: Biochemistry, Wolter Kluwer (India) Pvt Ltd, New Delhi
3. Lehninger AL, Nelson DL, and Cox MM. Lehninger's Principles of Biochemistry, WH Freeman and company, New York

4. Devlin TM, Textbook of Biochemistry with Clinical Correlations – Wiley-Liss, New York
5. Berg JM, Tymoczko JL, Stryer L. Biochemistry – WH Freeman and Company, New York
6. Voet D and Voet J, Biochemistry – John Wiley and Sons, New York,
7. Voet D and Voet J, Principles of Biochemistry, John Wiley and Sons, New York,
8. Marshall WJ, and Bangert SK, Clinical Chemistry: Metabolic and Clinical aspects, Mosby Elsevier, New York
9. Baynes JW and Dominiczak MH, Medical Biochemistry, Mosby Elsevier, New York
10. Bhagavan NV and Ha Chung-Eun, Essentials of Medical Biochemistry with clinical cases, Elsevier, New York
11. Smith CM, Marks AD, Lieberman M. Marks Basic Medical Biochemistry: A clinical Approach, Lippincott Williams and Wilkins, Philadelphia
12. Henry et al, Clinical chemistry
13. Chhabra Namrata, A case oriented approach towards Biochemistry, Jaypee Brothers Medical Publishers (P) Ltd. New Delhi
14. Montgomery R, Biochemistry: A case oriented approach, Mosby Harcourt Health Sciences Company, Sydney
15. Bruce Alberts. Molecular Biology of the Cell, Taylor and Francis, New York,
16. Bondy PK and Rosenberg LE, Duncans' Diseases of Metabolism, W B Saunders company, Philadelphia
17. Scriver CR., et al. Metabolic and Molecular basis of Inherited diseases, McGraw Hill International edition, New York

18. Rose BD, Clinical Physiology of acid-base and electrolyte disorders- McGraw Hill International edition, New York
19. Burtis CA and Ashwood ER, Tietz Fundamentals of Clinical Chemistry, Harcourt (India) Ltd.
20. Burtis CA, Ashwood ER, Burns DE. Tietz textbook of Clinical Chemistry and Molecular Diagnostics, Elsevier, Philadelphia
21. Kaplan LA and Pesee AG, Clinical Chemistry: Theory, analysis and Correlation – CV Mosby and Co. St Louis.
22. Gowenlock and Bell, Varley's Practical Clinical Biochemistry – CBS, New Delhi
23. Bishop ML, Fody EP, Schoeff LE, Clinical Chemistry; Techniques, Principles, Correlations, Wolter Kluwer (India) Pvt Ltd, New Delhi
24. Wilson Keith and Walker John, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press
25. Williamson MA, Snyder LM. Wallachs Interpretation of Diagnostic tests, Wolter Kluwer (India) Pvt Ltd, New Delhi
26. Watson JD, Molecular Biology of gene, Pearsons education, Singapore Pvt Ltd
27. Glick BR, Pasternak JJ, Molecular Biotechnology: Principles and applications of Recombinant DNA, ASM Press, Washington DC
28. Kuby Immunology, Judy Owen, Jenni Punt , Sharon Stranford, W. H. Freeman.
29. Harrison's Principles of Internal Medicine, Dennis L. Kasper, Anthony S.Fauci, Stephen L. Hauser, Dan L. Longo, J. Larry Jameson, Joseph Loscalzo, McGraw- Hill Education / Medical.
30. Davidson's Principles and Practice of Medicine, Walker, Elsevier Health Sciences – UK.

## **Suggested Journals**

03-05 international Journals and 02 national (all indexed) journals.

1. Clinical Chemistry
2. Annals of Clinical Biochemistry
3. Clinical Biochemistry
4. Clinica Chimica Acta
5. Journal of Clinical Investigation
6. Indian Journal of Clinical Biochemistry
7. Indian journal of Medical Biochemistry
8. Indian journal of Biochemistry and Biophysics
9. Indian journal of Human genetics
10. Indian Journal of Medical research
11. Annual Review of Biochemistry
12. Clinical chemistry reviews
13. Journal of Clinical Endocrinology and Metabolism
14. Translational research
15. Medical Education

## **ADDITIONAL READING:**

1. Mahajan BK, Methods in Biostatistics for Medical Students, 8th edition, New Delhi, Jaypee Brothers Medical Publishers, 2016.
2. Raveendran,B Gitanjali. A Practical approach to PG dissertation, New Delhi, J P Publications, 1998.

**Annexure 1**  
**Pre / Para /Clinical Disciplines**  
**Postgraduate Students Appraisal Form**

Name of the Department/Unit :

Name of the PG Student :

Period of Training : From.....To.....

Sr No.	PARTICULARS	Not Satisfactory		Satisfactory			More Than Satisfactory			Remarks
		1	2	4	5	6	7	8	9	
1.	Journal based / recent advances learning									
2.	Patient based /Laboratory or Skill based learning									
3.	Self-directed learning and teaching									
4.	Departmental and nterdepartmental learning activity									
5.	External and Outreach Activities / CMEs									
6.	Thesis / Research work									
7.	Log Book Maintenance									

Publications

Yes/ No

**Remarks\***

\*REMARKS: Any significant positive or negative attributes of a postgraduate student to be mentioned. For score less than 4 in any category, remediation must be suggested. Individual feedback to postgraduate student is strongly recommended.

**SIGNATURE of ASSESSEE    SIGNATURE OF CONSULTANT    SIGNATURE OF HOD**





SDM College of Medical Sciences & Hospital



SDM College of Dental Sciences & Hospital



SDM College of Physiotherapy &  
SDM Institute of Nursing Sciences



Shri Dharmasthala Manjunatheshwara University



SDM Research Institute for Biomedical Sciences



Panoramic View of Campus