SYLLABUS POST REVISION FOR MD BIOCHEMISTRY

SUSHIL KUMAR THAKUR

Digitally signed by SUSHIL KUMAR THAKUR
DN: C=IN, O=Personal, PostalCode=302033, S=Rajasthan, SERIALNUMBER=C973379113FC8D793F2708FC9D687F06B89F4196B9325326C00EECB6FEC22CC0, CN=SUSHIL KUMAR THAKUR
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NATIONAL MEDICAL COMMISSION
Postgraduate Medical Education Board

D 11011/1/22/AC/Guidelines/24 **Date: 16-11-2022**

National Medical Commission

GUIDELINES FOR COMPETENCY BASED POSTGRADUATE TRAINING PROGRAMME FOR MD IN BIOCHEMISTRY

SUSHIL KUMAR THAKUR
Digitally signed by SUSHIL KUMAR THAKUR
DN: C=IN, O=Personal, PostalCode=302033, S=Rajasthan, SERIALNUMBER=C973379113FC8D793F2708FC9D687F06B89F4196B9325326C00EECB6FEC22CC0, CN=SUSHIL KUMAR THAKUR
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GUIDELINES FOR COMPETENCY-BASED POSTGRADUATE TRAINING FOR MD IN BIOCHEMISTRY

Preamble

A competency is the capability to apply or use a set of related knowledge, skills, and abilities required to successfully perform "critical work functions" or tasks in a defined work setting. Competency-based training is a learning model in which the required level of knowledge and skill (competency) on a task must be demonstrated. The purpose of the competency-based postgraduate education in Biochemistry is to create specialists, with the required knowledge, skills, and attitude, who would provide high-quality healthcare complying with the principles of personal integrity and professional ethics and would advance the cause of science through teaching, research & training along with constant updating of his/her knowledge and skills as a lifelong self-directed learner.

The student, after undergoing training in MD Biochemistry, should be able to demonstrate his/her knowledge of the basic concepts and recent advances in the subject, and a defined set of skills including expertise in various laboratory techniques applicable to metabolic and molecular aspects of medicine, planning and executing research projects, writing research papers/ articles demonstrating the acquired training in research methodology. The postgraduate training course should equip the student with skills to become a competent teacher who is also able to demonstrate his/her competence in planning teaching programs and apply those to facilitate the learning of the students in medical and allied health science courses in compliance with the curriculum while advancing the same with needful and feasible innovations. He/she should demonstrate competence in integrating teaching-learning of Biochemistry with other relevant subjects/disciplines to facilitate the holistic application of the subject of Biochemistry in patient care. He/she should be able to demonstrate his/her training in good laboratory practices with the ability to set up/manage a quality-controlled and quality-assured diagnostic laboratory, generate, evaluate, interpret and report the diagnostic laboratory data, with a good understanding of the sciences,

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corrective and preventive actions, hospital and laboratory information system network, and interact with clinicians as may be needed for effective patient care.

This document aims to provide teachers and learners with comprehensive guidelines to achieve a defined set of outcomes through learning and assessment and apply those in a given setup. This document has been framed by the Expert Group of the National Medical Commission with an aim to render a uniform PG medical curriculum to be implemented by all the medical colleges in the country. The curriculum so designed has been named the competency-based PG medical education curriculum in conformity with the purpose and content of PG medical education.

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SUBJECT-SPECIFIC LEARNING OBJECTIVES

Goal:

The goal of the training program in MD Biochemistry is to enable a student to become a competent teacher/facilitator of teaching-learning processes, researcher, problem solver, and healthcare provider. He/ she should be able to acquire a defined set of cognition and skills as detailed below and demonstrate his ability to apply the same in a given healthcare setup.

a. Acquisition of Knowledge

The student should be able to explain the molecular, physical, and physiological logic of the processes involved in the maintenance of normal health and their deviation in a disease state. He/should be able to integrate his/her acquired knowledge in principles and concepts of classical biochemistry, biophysics, and molecular biology, comprehend and apply his/her cognition and skills in a professional patient care setup.

b. Acquisition of Skills

The student should be able to facilitate the UG and PG learning of biochemical concepts and principles and should be able to render hands-on training in the Biochemical laboratory investigations and experimentations relevant to the strengthening of biochemical concepts, scientific and clinical problem-solving, and biomedical research. He/she should be able to

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analyze, interpret and evaluate the data, and rationalize their application in clinical management and experimental research.

c. Teaching and training

As a competent healthcare personnel, the student should develop his/her learning skills by applying the fundamental principles of medical education, through teaching and assessing the undergraduate students in medicine and allied health science courses and, by contributing to the training of postgraduate students.

d. Diagnostic laboratory skills

The student should be competent in setting up/supervising/managing a diagnostic laboratory in Biochemistry in a hospital or in any other setup (diagnostic units in remote places or independent of a hospital setting) ensuring quality control along with quality assurance and providing reliable healthcare support services. The student should be able to provide consultation to clinicians and also contribute to community healthcare by conducting screening tests.

e. Professionalism, Ethics, Communication skills

The student should be able to develop and sustain work ethics and empathetic behavior with students and colleagues. He/she should be able to demonstrate professional integrity, honesty, and higher ethical standards and be able to display appropriate attitude and communication skills to interact with colleagues, teachers, students, laboratory personnel, and other healthcare professionals. While dealing with the patients and their relatives, he/she should exhibit compassion, care, and concern.

f. Research

The student should be able to demonstrate his/her competence in carrying out research work and related activities from the planning phase to writing (dissertation/thesis, research report/research paper) by applying the principles of research methodology.

LEARNING OBJECTIVES

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At the end of three years of training in the MD Biochemistry course, a postgraduate student should be able to:

- Demonstrate his/her knowledge of Biochemistry, Cell Biology, Molecular Biology, Molecular diagnostics, Biophysics, and applied aspects of all the mentioned branches to contribute to the teaching-learning processes and healthcare management.
- Identify learning needs and set the learning objectives for his/her self-directed learning and acquire and apply the needful learning in subjects like Genetics, Nutrition & Dietetics, Immunochemistry, and Laboratory Medicine in a relevant context.
- Apply the Medical Education principles to effectively contribute to Teaching-Learning processes, Assessment & Integrated learning.
- Demonstrate his/her knowledge about various aspects of the Competency-based UG medical education implemented w.e.f academic year 2019-20.
- Explain, comprehend and analyze the basics of Cellular and Molecular Biochemistry, functional mechanisms of the biomolecules and their logistics in the human body in normal health and their deviations in the disease conditions. He/she should be able to integrate his/her cognition and skills to facilitate medical education for undergraduate, postgraduate, and allied health sciences students and for patient management.
- Demonstrate administrative, decision-making, group activity, teamwork, and leadership skills in (a) setting up a department in the medical institution and (b) diagnostic services in the hospital and managing them as a part of the healthcare team.
- Analyze, interpret and evaluate laboratory data and provide consultancy to the clinician for judicious use of lab tests, with appropriate interpretation whenever needed, to facilitate the diagnosis, treatment, follow-up, and overall management of patients.
- Conduct research and related activities in the field of Biochemistry, Clinical Biochemistry, Molecular diagnostics, and Medical Education.
- Analyze, interpret, evaluate, appraise and present research-related data and publications to identify the best clinical evidence for research and demonstrate his/her competence in scientific /clinical work presentation.
- Describe the principles of evidence-based medicine, evidence-based practice, good laboratory practice, and good clinical practice.

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- Communicate effectively to fellow colleagues, teachers, patients & their relatives and other healthcare members for providing services to the community.
- Actively participate in all the teaching-learning-related activities like CMEs/workshops/conferences/hands-on-training/Interdepartmental meets/clinical meetings and acquire interpersonal skills.

SUBJECT/DOMAIN-SPECIFIC COMPETENCIES

At the end of three years training course, the postgraduate student should be able to demonstrate the competencies under the following three domains:

A. Cognitive domain (Knowledge domain)

1. Describe the biochemical principles and mechanisms to define and explain a healthy, and a diseased state, and execute the application of the biochemical mechanisms in the perception, diagnosis, and treatment of a disease.
2. Describe the biomolecules and their importance in sustaining life processes.
3. Explain the concept of intermediary metabolism, energy transactions, and metabolic and molecular homeostasis in the sustenance of life.
4. Explain the characteristics, components, and functional significance of different metabolic pathways, their specific intermediates, their inter-conversions, pathway-specific, organ-specific, and interrelated regulation of metabolic pathways, and apply that in explaining the biochemical logic in the functioning of the body in health and disease.
5. Describe and apply the concept of nutrition in health and disease, and critically evaluate the role of essential micro- and macro-nutrients, and their interlinks with cellular metabolism.
6. Apply the integrated knowledge and understanding of biochemical principles and mechanisms in clinical problem-solving.
7. Demonstrate knowledge of genetic engineering in various fields of medicine.
8. Apply the principles of biostatistics in research, clinical laboratory practices, community-based health data collection, and epidemiological surveys.
9. Demonstrate knowledge of the establishment of a diagnostic laboratory and its accreditation process.

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10. Analyze, interpret and evaluate biochemical laboratory findings in integration with the relevant clinical data to evaluate, analyze and monitor a disease state.
11. Apply the knowledge acquired in the basic principles of research methodology to develop a research protocol.
12. Make use of the latest available statistical tools for analyzing the research data, and interpreting and disseminating the results.
13. Demonstrate familiarity with the advances in artificial intelligence and computer-based modeling as and when required.
14. Describe and implement various components of the Competency-based UG Medical Education.
15. Apply the principles of teaching-learning technology while taking interactive classroom lectures, prepare modules for case-based learning (CBL) and problem-based learning (PBL), organize and conduct CBLs/PBLs, case discussions, small group discussions, seminars, journal clubs, and research presentations.
16. Explain the principles of instrumentation and their automation in the Biochemistry laboratory and demonstrate knowledge about the latest advances in technology.
17. Exhibit knowledge of professional ethics and integrity in his/her day-to-day conduct and services rendered.
18. Apply the updated knowledge to suggest and implement judicious use of clinical laboratory investigations.
19. Demonstrate knowledge on the use of laboratory gadgets and instruments taking necessary precautions.
20. Demonstrate knowledge on the preparation of solutions and reagents with necessary precautions as may be required for the estimations in experimental and diagnostic laboratories.
21. Display knowledge about recent advances and trends in the core subject area, research, and laboratory practice along with point-of-care testing (POCT) in the field of biochemistry.

B. Affective domain (Attitudes including Communication and Professionalism)

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1. Communicate appropriately with peers, teachers, healthcare professionals, and patients coming from a variety of backgrounds to explain the molecular and metabolic basis of health and disease in integration with lifestyle management.
2. Demonstrate care, concern, respect, empathy, and compassion while dealing with patients and their relatives at any point of interaction.
3. Demonstrate progressive improvement in AETCOM in routine endeavors through self-assessment, feedback from the peers, stakeholders and adapting to relevant learning.
4. Explain effectively to the patients/their relatives the precautions and preparations needed for them to comply with for specific biochemical analysis/laboratory tests that they will be subjected to.
5. Ensure that the related technical staff is apprised of the above and is duly trained while dealing with the patients.
6. Apply ethical principles and display proper etiquette in dealing with patients, relatives, and other health personnel.
7. Demonstrate appropriate attitude and ethical behavior in exchanging feedback with peers, teachers, clinicians, patients, and their relatives.
8. Display ethical behavior, and personal and professional integrity in his/her conduct and services.
9. Demonstrate the ability to maintain confidentiality in declaring the laboratory results to the concerned personnel wherever applicable.
10. Display awareness and respect for the rights of the patients.
11. Demonstrate counseling skills, especially in the context of nutritional and genetic counseling.
12. Demonstrate competency in judicious decision-making free from personal beliefs/thoughts, pride, and prejudice and, that, no such limitations impact his/her professional performance.

C. Psychomotor domain

1. Demonstrate the principles and facts of cellular and molecular biochemistry by performing relevant laboratory exercises and analytical tests on body fluids, and other

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biologically important substances, along with documentation of the test procedures, results, and interpretation of findings.

2. Develop a differential diagnosis, wherever applicable, based on the results obtained after performing the requisite tests.
3. Plan & conduct lectures, practical demonstrations, tutorial classes, and case-based or problem-based small group discussions for undergraduate students of medical and allied disciplines.
4. Identify, select and perform various biochemical tests in the clinical laboratory which are useful in the diagnosis, treatment, follow-up, and overall management of diseases and be able to interpret the results of such tests.
5. Perform relevant biochemical, immunological, and molecular biology techniques, wherever applicable.
6. Demonstrate compliance with the standard operating procedures of various methods and techniques used in a clinical biochemistry laboratory.
7. Perform enzymatic assays and conduct experiments to study enzyme kinetics affirming the ability to discuss, interpret and document the related data.
8. Perform routine investigations in hematology and microbiology, as and when required.
9. Demonstrate presentation skills at academic meetings and scientific paper writing skills.
10. Prepare research protocols and conduct relevant experimental studies.
11. Analyze and solve clinical and experimental problems.

By the end of the course, the postgraduate student should be able to demonstrate his competency in performing the following procedures independently:

- Demonstrate the use of all the routine glassware/equipment used in UG teaching-learning in Biochemistry (as per MSR) and advanced instruments used in the clinical laboratory attached to the respective hospital for patient care.
- Preparation of buffers, normal laboratory solutions like molar/molal/normal and reagents with validation.
- Perform all the undergraduate practicals as per the new competency-based medical education prescribed by NMC.

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- Perform experiments to study selected reactions of carbohydrates, amino acids and proteins, and lipids.
- Perform experiments to demonstrate constituents of milk.
- Perform experiments to demonstrate normal and abnormal constituents of urine.
- Perform Paper chromatography for separation of amino acids.
- Determination of enzyme activity and study of enzyme kinetics, using any two suitable enzymes (e.g., alkaline phosphatase from any liver tissue or acid phosphatase from potatoes).
- Plot standard curve for different estimations.
- Estimate (including calibration) and interpret clinical analytes as detailed below:
    - Blood glucose, glycated hemoglobin, the performance of glucose tolerance test and glucose challenge test,
    - Total protein, albumin, and A:G ratio,
    - Electrolytes, arterial blood gas analysis,
    - Cholesterol, triglycerides, free fatty acids, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), phospholipids, Lp(a), and calculated parameters under lipid profile,
    - Amylase, lipase,
    - Urea, creatinine, uric acid, urinary microalbumin,
    - Parameters of liver function tests (bilirubin, hepato-biliary enzymes such as AST, ALT, ALP, GGT, serum proteins/albumin and prothrombin time, CRP),
    - Calcium, magnesium, phosphorus, copper (and ceruloplasmin), serum iron, TIBC, and ferritin,
    - Markers of myocardial damage (CK, CK-MB, troponins, LDH),
    - Vitamin D, $B_{12,}$ and folate,
    - Point-of-care testing (POCT).
- Electrophoresis of serum proteins**,** lipoproteins,
- Separation and molecular weight determination of proteins by SDS-PAGE,
- Electrophoretic separation of LDH isozymes or any other isoenzymes,
- Hb electrophoresis,

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- Renal clearance tests,
- CSF and other body fluid analysis,
- Stone analysis,
- Thyroid function tests, Tumor markers, and relevant hormone assays by ELISA/RIA/Chemiluminescence.

Clinical Laboratory

- Demonstrate familiarity with the essentials of a clinical laboratory setup, the working of autoanalyzer, data transfer, statistical considerations, authorizing and reporting results in an advanced clinical laboratory with an ability to enlist the possible sources of errors (pre-analytical, analytical and post-analytical), perform root cause analysis, and undertake corrective actions, and preventive actions (CAPA).
- Perform and demonstrate activities under total quality management (TQM) of the Laboratory:
  a. Specimen collection, handling, processing, and storage of the sample.
  b. Methods of standardization & calibration.
  c. Methods of quality control, quality assurance, CAPA & assessment.
- Demonstrate ability to prepare and interpret a Levy-Jennings chart and plot inter-assay and intra-assay variation for any analyte estimated in the laboratory.
- Implementation and interpretation of Westgard rules followed by their CAPA, as required.
- Determination of reference values for any one parameter for the clinical laboratory.
- Perform inter-instrumental comparison for at least four parameters.
- Perform in-house calibration of pipettes, centrifuge, hot-air oven, thermometer, and thermo-hygrometer.
- Student should undergo internal auditor training as per ISO 15189:2012, NABL (optional).
- Able to prepare a lab quality manual and frame relevant Standard Operating Procedure (SOP) and Work Desk Instructions (WDI), for every procedure followed in a clinical lab.

Molecular laboratory techniques

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The student should be able to perform the following:

- Isolation of genomic DNA from blood,
- Isolation of RNA, synthesis of cDNA by reverse transcription,
- PCR and Reverse transcriptase PCR (both conventional and real-time),
- Primer designing,
- Blotting techniques,
- Basic techniques and principles of protein/enzyme purification and determining homogeneity.

By the end of the course, the postgraduate student should be able to perform under supervision or, demonstrate familiarity with, as the case may be, the following procedures (at least any five):

1. Separation of peripheral blood leukocytes using relevant isolation technique,
2. Subcellular fractionation/marker enzymes for organelles to demonstrate fractionation and purity of the fraction,
3. Ultracentrifugation,
4. Isolation of plasmids,
5. Basic techniques and essentials in cell culture and establishing different cell culture facilities,
6. High-performance liquid chromatography (HPLC)/GC-MS/LC-MS,
7. Restriction fragment length polymorphism (RFLP),
8. Fluorescent in-situ hybridization (FISH),
9. DNA fingerprinting,
10. Immunodiffusion techniques,
11. Immuno-electrophoresis,
12. Therapeutic drug monitoring,
13. Flow cytometry,
14. Nephelometry,
15. HLA typing.

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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.

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- 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

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- 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.

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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,

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- 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.

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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,

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- 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.

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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.

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- 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

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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.

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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

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- 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

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- 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.

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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

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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, adenohypophyseal 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.

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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.***

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B. Psychomotor Domain

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

TEACHING AND LEARNING METHODS

General principles

Acquisition of competencies being the keystone of doctoral medical education, such training should be skill oriented. Learning in the program, essentially autonomous and self-directed, and emanating from academic and clinical work, shall also include assisted learning. The formal sessions are meant to supplement this core effort.

All students joining the postgraduate (PG) courses shall work as full-time (junior) residents during the period of training, attending not less than 80% of the training activity during the calendar year, and participating in all assignments and facets of the educational process. They shall maintain a logbook for recording the training they have undergone, and details of the procedures done during laboratory and clinical postings in real-time.

Teaching-Learning methods

This should include a judicious mix of demonstrations, symposia, journal clubs, clinical meetings, seminars, small group discussion, bed-side teaching, case-based learning, simulation-based teaching, self-directed learning, integrated learning, interdepartmental meetings and any other collaborative activity with the allied departments. Methods with exposure to the applied aspects of the subject relevant to basic/clinical sciences should also be used. **The suggested examples of teaching-learning methods are given below but are not limited to these. The frequency of various below-mentioned teaching-learning methods can vary based on the subject's requirements, competencies, workload, and overall working schedule in the concerned subject.**

A. Lectures: Didactic lectures should be used sparingly. A minimum of 10 lectures per year in the concerned PG department is suggested. Topics to be selected as per subject requirements.

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All postgraduate trainees will be required to attend these lectures. Lectures can cover topics such as:

1. Subject related important topics as per specialty requirement
2. Recent advances
3. Research methodology and biostatistics
4. Salient features of Undergraduate/Postgraduate medical curriculum
5. Teaching and assessment methodology.

Topic numbers 3,4,5 can be done during research methodology/biostatistics and medical education workshops in the institute.

B. Journal club: Minimum of once in 1-2 weeks is suggested.

Topics will include presentation and critical appraisal of original research papers published in peer reviewed indexed journals. The presenter(s) shall be assessed by faculty and grades recorded in the logbook.

C. Student Seminar: Minimum of once every 1-2 weeks is suggested.

Important topics should be selected as per subject requirements and allotted for in-depth study by a postgraduate student. A teacher should be allocated for each seminar as faculty moderator to help the student prepare the topic well. It should aim at comprehensive evidence-based review of the topic. The student should be graded by the faculty and peers.

D. Student Symposium: Minimum of once every 3 months.

A broad topic of significance should be selected, and each part shall be dealt by one postgraduate student. A teacher moderator should be allocated for each symposium and moderator should track the growth of students. The symposium should aim at an evidence-based exhaustive review of the topic. All participating postgraduates should be graded by the faculty and peers.

E. Laboratory work / Bedside clinics: Minimum-once every 1-2 weeks.

Laboratory work/Clinics/bedside teaching should be coordinated and guided by faculty from the department. Various methods like DOAP (Demonstrate, Observe, Assist, Perform),

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simulations in skill lab, and case-based discussions etc. are to be used. Faculty from the department should participate in moderating the teaching-learning sessions during laboratory work.

F. Interdepartmental colloquium

Faculty and students must attend monthly meetings between the main department and other department/s on topics of current/common interest or clinical cases.

G. a. Rotational clinical / community / institutional postings

Depending on local institutional policy and the subject specialty needs, postgraduate trainees may be posted in relevant departments/ units/ institutions. The aim would be to acquire more in-depth knowledge as applicable to the concerned specialty. Postings would be rotated between various units/departments and details to be included in the specialty-based Guidelines.

Suggested departments and duration of rotational postings:

- General Medicine - 1 month (includes Endocrinology, Pediatrics, and ICU posting)
  - ✓ Endocrinology [Focus: Clinical correlation and important investigations related to diabetes mellitus and other diseases, dietary advice, point-of-care testing]
  - ✓ ICU/ICCU [Focus: ABG analysis and correlation, electrolyte imbalances, cardiac biomarkers and correlation, markers of septicemia and its management, basics of ventilation]
  - ✓ Pediatrics [Focus: Inborn errors of metabolism and other common diseases, nutritional disorders, and dietary advice]
- Hematology - 15 days
- Immunohematology and blood transfusion (Transfusion Medicine)/Blood bank - 15 days
- Microbiology- 15 days
- Medical Education Unit (MEU) or Department of Medical Education (DOME) - one week/ shall attend a specific workshop or a training course [Focus:

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Principles of teaching-learning-assessment and other important aspects of Medical Education].

G.b. Posting under "District Residency Programme" (DRP):

All postgraduate students pursuing MD/MS in broad specialties in all Medical Colleges/Institutions shall undergo a compulsory rotation of three months in the District Hospital/District Health System as a part of the course curriculum, as per the Postgraduate Medical Education (Amendment) Regulations (2020). Such rotation shall take place in the 3rd or 4th or 5th semester of the Postgraduate program and the rotation shall be termed as "District Residency Programme" and the PG medical student undergoing training shall be termed as "District Resident".

Every posting should have its defined learning objectives. It is recommended that the departments draw up objectives and guidelines for every posting offered in conjunction with the collaborating department/s or unit/s. This will ensure that students acquire expected competencies and are not considered as an additional helping hand for the department / unit in which they are posted.The PG student must be tagged along with those of other relevant departments for bedside case discussion/basic science exercises as needed, under the guidance of an assigned faculty.

Opportunities to present and discuss infectious disease cases through bedside discussion and ward/grand rounds with specialists/clinicians in different hospital settings must be scheduled to address antimicrobial resistance issues and strategies to deal with it.

H. Teaching research skills

Writing a thesis should be used for inculcating research knowledge and skills. All postgraduate students shall conduct a research project of sufficient depth to be presented to the University as a postgraduate thesis under the supervision of an eligible faculty member of the department as a guide and one or more co-guides who may be from the same or other departments.

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In addition to the thesis project, every postgraduate trainee shall participate in at least one additional research project that may be started or already ongoing in the department. It is preferable that this project will be in an area different from the thesis work. For instance, if a clinical research project is taken up as thesis work, the additional project may deal with community/field/laboratory work. Diversity of knowledge and skills can thereby be reinforced.

I. Training in teaching skills

MEU/DOME should train PG students in education methodologies and assessment techniques. The PG students shall conduct UG classes in various courses and a faculty shall observe and provide feedback on the teaching skills of the student.

J. Log book

During the training period, the postgraduate student should maintain a logbook indicating the duration of the postings/work done in wards, OPDs, casualty, and other areas of the posting. This should indicate the procedures assisted and performed and the teaching sessions attended. The logbook entries must be done in real-time. The logbook is thus a record of various activities by the student like (1) Overall participation & performance, (2) attendance, (3) participation in sessions, (4) record of completion of pre-determined activities, and (5) acquisition of selected competencies.

The purpose of the logbook is to:

a) help maintain a record of the work done during training,

b) enable faculty/consultants to have direct information about the work done and intervene, if necessary,

c) provide feedback and assess the progress of learning with experience gained periodically.

The logbook should be used in the internal assessment of the student, and should be checked and assessed periodically by the faculty members imparting the training. The PG students will be required to produce a completed log book in original at the time of final practical examination. It should be signed by the Head of the Department. A proficiency certificate

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from the Head of Department regarding the clinical competence and skillful performance of procedures by the student will be submitted by the PG student at the time of the examination.

The PG students shall be trained to reflect and record their reflections in the logbook particularly of the critical incidents. Components of good teaching practices must be assessed in all academic activity conducted by the PG student and atleast two sessions dedicated for assessment of teaching skills must be conducted every year of the PG program. The teaching faculty are referred to the NMC (Erstwhile MCI) Logbook Guidelines uploaded on the website.

K. **Course in Research Methodology**: All postgraduate students shall complete an online course in Research Methodology within six months of the commencement of the batch and generate the online certificate on successful completion of the course.

Other aspects

- The postgraduate trainees must participate in the teaching and training program of undergraduate students and interns attending the department.
- Trainees shall attend accredited scientific meetings (CME, symposia, and conferences) at least once a year.
- Department shall encourage e-learning activities.
- The postgraduate trainees should undergo training in Basic Cardiac Life Support (BCLS) and Advanced Cardiac Life Support (ACLS).
- The postgraduate trainees must undergo training in information technology and use of computers.

During the training program, patient safety is of paramount importance; therefore, relevant clinical skills are to be learned initially on the models, and later to be performed under supervision followed by independent performance. For this purpose, the provision of skills laboratories in medical colleges is mandatory.

ASSESSMENT

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The assessment for postgraduate student in Biochemistry will be of two types; Formative and Summative

FORMATIVE ASSESSMENT

Formative assessment is the assessment conducted during the training with the primary purpose of providing feedback for improving learning. It should be continual and should assess medical knowledge, patient care, procedural & academic skills, interpersonal skills, professionalism, self-directed learning, and ability to practice in the system. The formative assessment will be used to determine the existing knowledge base and future needs, and identify priority areas.

General Principles

The Internal Assessment will include both theory and practical examination. It should be frequent, cover all domains of learning, and should be used to provide feedback to improve learning; it should also cover professionalism and communication skills.

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Formative assessment during the MD training should be based on:

- Case presentation/case work up : once a week
    - The student will present a case from ward/lab along with investigations done in the clinical laboratory
- Laboratory performance : once a week
    - The student will analyze an unknown sample on an autoanalyzer, starting with calibration, quality control of the machine, and then loading the sample. He/she will do the reporting and interpret the results and will be evaluated the next day.
    - He/she will be evaluated separately for practicals listed in the undergraduate syllabus.
    - He/she will be evaluated at the end of each postgraduate practical session as listed under the psychomotor domain.

- Journal club : once a quarter

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- The student will present and critically evaluate an original research article. The article should be preferably from outside his/her area of work so that he/she can learn newer techniques. The focus should be on understanding the research question and evaluating whether appropriate study design, methodology, and statistical tools were used to find answers to the same.

- Seminar : once a fortnight
  - The student will present a topic from the syllabus and will try to research and include recent advances on that topic. He/she will also present recent advances (not included in the syllabus) periodically.
- Micro-teaching : Once a week
  - The teaching skills of the student will be evaluated. Special topics can be given, and the student will teach that topic to the evaluators or he/she may be evaluated during pre-practical briefing of undergraduate students.
- Interdepartmental case or seminar : once in 3 months
  - This should be organized at the institute level and appropriate vertical and horizontal integration should be ensured.

  Note: These sessions may be organized and recorded as an institutional activity for all postgraduates.
- AETCOM : Once in every six months
  - The postgraduate student can be evaluated during the AETCOM sessions of the undergraduates.
  - Case scenarios should be provided and the postgraduate will be asked to demonstrate how he/she will respond to the situation.

- Attendance at Scientific meetings, CME programmes (at least 02 each during the course)

The student is to be assessed periodically as per categories listed in the appropriate (non-clinical/clinical) postgraduate student appraisal form (Annexure I).

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SUMMATIVE ASSESSMENT, ie., assessment at the end of training to evaluate whether the student has acquired sufficient knowledge and skills to be awarded MD degree

Essential pre-requisites for appearing for examination include:

1. **Logbook** of work done during the training period including rotational postings, departmental presentations, and reports of the internal assessment conducted during the training period should be submitted.

2. At least **two presentations** at national-level conferences. One research paper should be under submission for publication/ accepted for publication/ published in an indexed journal**. (It is suggested that the local or University Review committee assess the work sent for publication).**

The summative examination would be carried out as per the rules given in the latest POSTGRADUATE MEDICAL EDUCATION REGULATIONS. The theory examination shall be held in advance before the clinical and practical examination so that the answer books can be assessed and evaluated before the commencement of the clinical/practical and oral examination**.**

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

1. **Thesis**

   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 examination. A post graduate student in broad specialty shall be allowed to appear for the Theory and Practical/Clinical examination only after the acceptance of the Thesis by the examiners**.**

2. **Theory examination**

   The examinations shall be organized on the basis of ‘Grading’ or ‘Marking system’ to evaluate and certify post-graduate student's level of knowledge, skill, and competence at the end of the training, as given in the latest POSTGRADUATE MEDICAL

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EDUCATION REGULATIONS. Obtaining a minimum of 50% marks in 'Theory' as well as 'Practical' separately shall be mandatory for passing the examination as a whole. The examination for M.D./ M.S shall be held at the end of the 3rd academic year.

There shall be four theory papers (as per PG Regulations):

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.

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

Paper III:
Molecular biology, Molecular and genetic aspects of cancer, Immunology, and Environmental Biochemistry

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

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3. Practical/clinical and Oral/viva voce examination

Practical examination

The practical examination should be spread over **two** days and include various major components of the syllabus focusing mainly on the psychomotor domain. One day should be for conducting practical examination including table viva that will focus on the nuances of laboratory techniques and quality assurance.

The practical examination should include:

1. One Clinical / Paper case: An unknown sample will be analyzed by the student, and he/she will have to prepare the report along with the interpretation of the same. It should include both serum and urine analysis.
2. One practical exercise on any molecular biology technique.

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3. One practical exercise on immunology technique.
4. OSPE: It shall be conducted on various topics which have not been covered in the above-mentioned practical and should include, if possible, evaluation of AETCOM (Attitude, Ethics, and Communication) skills of the students.
5. Evaluation of laboratory management skills.

Oral/Viva voce examination on defined areas should be conducted by each examiner separately. The oral examination shall be comprehensive enough to test the postgraduate student's overall knowledge of the subject focusing on the psychomotor and affective domains.

The **Oral/Viva-voce examination shall be conducted on the second day and should include:**

1. Thesis presentation

   The ability of the student to justify the methodology, and findings with interpretation, should be evaluated.
2. Micro-teaching

   The essentials of classroom teaching skills should be evaluated.
3. Grand viva voce

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Recommended Reading:

Books (latest edition)

1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox. W H Freeman & Co (Sd).
2. Biochemistry (Stryer), Jeremy M. Berg , John L. Tymoczko , Lubert Stryer, W. H. Freeman.
3. Biochemistry (Voet & Voet), Donald Voet , Judith G. Voet, John Wiley & Sons Inc.
4. Textbook of Biochemistry with Clinical Correlations, Thomas M. Devlin, John Wiley & Sons.
5. Kuby Immunology, Judy Owen, Jenni Punt , Sharon Stranford, W. H. Freeman.
6. Principles and Techniques of Biochemistry and Molecular Biology. Wilson/Walker; Cambridge University Press

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7. Clinical Chemistry: Principles, Techniques, and Correlations, Michael L Bishop, Edward P Fody, Larry E Schoeff, Lippincott Williams and Wilkins.
8. Tietz Textbook of Clinical Chemistry and Molecular Diagnostics, Carl A. Burtis, Edward R. Ashwood , Saunders.
9. Harpers Illustrated Biochemistry, Victor W. Rodwell , David Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil , McGraw-Hill Education / Medical.
10. Biochemistry (Lippincott's Illustrated Reviews), Denise R Ferrier, Lippincott Williams and Wilkins.
11. 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.
12. Davidson's Principles and Practice of Medicine, Walker, Elsevier Health Sciences – UK.
13. Clinical Biochemistry: Metabolic and Clinical Aspects, William J. Marshall & Márta Lapsley & Andrew Day & Ruth Ayling, Imprint - Churchill Livingstone.
14. Biochemistry: A Case-oriented Approach, Rex Montgomery, Thomas W. Conway, Arthur A. Spector, David Chappell, Mosby.
15. Interpretation of Diagnostic tests, Jacques Wallach, Lippincott Williams & Wilkins.

Journals

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

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Annexure 1

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Student appraisal form for MD in Biochemistry

	Elements	Less than Satisfactory			Satisfactory			More than satisfactory			Comments
		1	2	3	4	5	6	7	8	9	
1	**Scholastic aptitude and learning**										
1.1	Has knowledge appropriate for level of training										
1.2	Participation and contribution to learning activity (e.g., Journal Club, Seminars, CME etc)										
1.3	Conduct of research and other scholarly activity assigned (e.g Posters, publications etc)										
1.4	Documentation of acquisition of competence (eg Log book)										
1.5	Performance in work based assessments										
1.6	Self-directed Learning										
2	**Work related to training**										
2.1	Practical skills that are appropriate for the level of training										
2.2	Respect for processes and procedures in the work space										
2.3	Ability to work with other members of the team										
2.4	Participation and compliance with the quality										

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	improvement process at the work environment										
2.5	Ability to record and document work accurately and appropriate for level of training										
3	**Professional attributes**										
3.1	Responsibility and accountability										
3.2	Contribution to growth of learning of the team										
3.3	Conduct that is ethically appropriate and respectful at all times										
4	**Space for additional comments**										
5	**Disposition**										
	Has this assessment pattern been discussed with the trainee?	Yes	No								
	If not explain.										
	Name and Signature of the assesse										
	Name and Signature of the assessor										
	Date										

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Subject Expert Group members for preparation of REVISED Guidelines for competency based postgraduate training programme for MD in Biochemistry

1. **Dr. Nibrithi Das**, **Convener**
   Professor (Retd), Dept. Biochemistry,
   All India Institute of Medical Sciences,
   New Delhi-110029

2. **Dr. Tejas J. Shah** **Co-convener**
   Professor and Head,
   Department of Biochemistry,
   Smt. B. K. Shah Medical Institute & Research Centre
   Sumandeep Vidyapeeth Deemed to be University
   At. & Po. Piparia, Taluka: Waghodia,
   Vadodara-391760, Gujarat State.

3. **Dr. Rajarshi Kar** **Member**
   Professor of Biochemistry
   UCMS & GTB Hospital
   Delhi-110095

4. **Dr. Vaishali Jain** **Member**
   Professor and Head, Department of Biochemistry,
   Atal Bihari Vajpayee Govt. Medical College,
   Vidisha, Madhya Pradesh

5. **Dr. Kiran Dahiya** **Member**
   Professor, Department of Biochemistry
   Pt BD Sharma PGIMS, Rohtak, Haryana-124001.

Dr. Nibhriti Das (Convenor) ; Dr. Tejas Shah (Co-convenor)

Dr. Rajarshi Kar, Dr. Kiran Dahiya , Dr. Vaishali Jain (Members, of the expert team)

SUSHIL KUMAR THAKUR

Digitally signed by SUSHIL KUMAR THAKUR
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