

BIOCHEMISTRY

Goal:

The main goal of learning Biochemistry is to enable an MBBS undergraduate student to have a comprehensive knowledge of various biomolecules present in human body cells. To orient them towards molecular level of all the biochemical reactions associated with living cells and applies this knowledge in maintenance of health and effective treatment of diseases.

Learning Objectives:

At the end of the course the student should be able to:

- 1) Describe the structural and functional organization of cell and its sub cellular components.
- 2) Understand the chemistry and biological significance of various biomolecules like Carbohydrates, Proteins, Lipids, Vitamins etc.
- 3) Have a sound knowledge of Enzymes in respect to mechanism of action, classification and their use in medicine.
- 4) Have clear concept about nutrition, food ingestion, digestion, absorption, interconversions and assimilation of various nutrients in our diet.
- 5) Know metabolisms of major biomolecules with their integration and regulations in well fed and starvation conditions of human body.
- 6) Be able to comprehend genes, their expression, the principles and the application of genetic engineering.
- 7) Be able to understand biochemical basis of inherited disorders, inborn errors of various metabolisms and their associated sequelae.
- 8) Know the mechanism of energy metabolism, body defense, detoxification and homeostasis of body fluids and pH.
- 9) Have thorough understanding about nutrition in respect with vitamins, minerals, malnutrition and obesity.
- 10) Be able to outline biochemical basis of cancer, free radicals, radioisotopes and environmental health hazards.

11) Have knowledge of various Organ Function Tests- LFT, KFT, GFT, CFT, TFT and PFT to assess the functional status of organ systems.

12) Get good understanding of Clinical Biochemistry and its role and get familiar with conventional and specialized biochemical investigations and instrumentation, analysis and their clinical interpretations.

Skills:

At the end of the course the student should be able to:

- 1) Handle routine biochemical instruments/techniques, which are used in Clinical Biochemistry Laboratory for confirming the clinical diagnosis.
- 2) Analyze the biochemical reports/data with proper interpretations
- 3) Demonstrate commonly done biochemical screening tests.
- 4) Demonstrate the skills of solving clinical based problems with reference to biochemical investigations.

Integration:

The knowledge acquired in Biochemistry during the course should help the student to recognize and state the correlation of the Anatomical and Physiological features of the human body with Biochemical functions.

Further the knowledge of Biochemistry should make the students to integrate it with other subjects of Medicine for better understanding the biochemical basis and molecular events taking place in human body during health and disease.

Attitude:

The student must be able to:

- A. Develop a scientific approach in the practice of clinical medicine.
- B. Diagnose disorders on basis of biochemical investigation reports.
- C. Correlate disease manifestations with derangements of biochemical mechanisms and understand rationale of treatment.

BIOCHEMISTRY COURSE CONTENT THEORY

Introduction to Biochemistry

- Introduction to Biochemistry as a basic science for the study of Medicine
- Historical Aspects and Pioneer workers in field to develop Biochemistry
- Importance of Human Biochemistry in clinical practice

1. Biochemistry of Cell:

Must Know:

- Eukaryotic Cell and Subcellular organelles
- Structure and function of cell membrane
- Basics of various transport mechanisms
- Biochemical basis of structure and functions of sub cellular organelles

Should Know:

- Differentiation between Prokaryotic and Eukaryotic Cell

May Know:

- Disorders related to cellular and subcellular organ defects

2. Chemistry of Carbohydrates

Must Know:

- Definition and Classification of Carbohydrates
- Biomedical Important Carbohydrates and their significance

Should Know:

- **Monosaccharides** – Structure, Classification and their Significance.
- **Oligosaccharides** – Disaccharides: Structure and importance
 - Maltose
 - Lactose
 - Sucrose
- **Polysaccharides** –
- **Homopolysaccharides:** Structure, Occurrence and Functions
 - Starch
 - Glycogen
 - Cellulose

- Dextrin
- Dextran
- Inulin
- **Mucopolysaccharides:** Structure, Occurrence and their importance:
 - Hyaluronic acid
 - Heparin
 - Chondroitin Sulphate
 - Dermatan Sulphate
 - Keratan Sulphate
 - Blood group substances

May Know:

- Isomerism
- Physical and Chemical Properties Glucose
- Glucose Derivatives
- Glycosides and their importance

3. Chemistry Lipids

Must Know:

- Definition and Classification of Lipids
- Biomedically important body Lipids and their roles

Should Know:

- Structure and Functions of:
 - Simple Lipids
 - Compound Lipids
 - Derived Lipids

May Know:

- Eicosanoids
- Rancidity
- Tests purity of Oils

Chemistry of Proteins and Amino acids:

Must Know:

- Definition of Amino acids and Proteins
- Various modes of Classification with suitable examples
- Biomedical Importance of Body Proteins

Should Know:

- Structural organization of protein molecules
- General nature of amino acids
- Properties of amino acids and Proteins
- Plasma Proteins-functions

May Know:

- Non Proteogenic amino acids
- Biologically important peptides, Neurotransmitters
- Classification of proteins
- Properties and biological importance of proteins
- Methods of Protein separations and clinical significance

4. Chemistry of Nucleoproteins

Must Know:

- Definition of Nucleoproteins
- Nucleic Acids: Types, Components, Structure and Functions

Should Know:

- Biologically important free Nucleotides and their functions
- Synthetic Nucleotides and their importance

May Know:

- Various forms of DNA and RNA

5. Chemistry of Hemoglobin

Must Know:

- Hemoproteins of Human body
- Chemistry, Occurrence and Functions of Hemoglobin and Myoglobin

Should Know:

- Oxygen Dissociation Curve and Factors affecting it
- Normal Hemoglobin variants
- Hemoglobin derivatives: Normal and Abnormal

6. Metabolism of Hemoglobin

Must Know:

- Biosynthesis and breakdown of Hemoglobin
- Formation and Fate of Bilirubin

Should Know:

- Hemoglobinopathies
- Porphyrias
- Different types of Jaundice

May Know:

- Congenital Hyperbilirubinemias

7. Enzymes

Must Know:

- Enzyme: Definition, Classification
- Enzyme Nomenclature
- Nature of active site
- Coenzymes, Cofactors and Proenzymes
- Enzyme properties and Types

Should Know:

- Mechanism of enzyme action
- Factors affecting enzyme activity
- Enzyme specificity
- Enzyme Regulation and Inhibition
- Organ Specific and Plasma specific Enzymes
- Diagnostic and Therapeutic Uses of Enzymes
- Isoenzymes with respect to LDH, CPK, ALP
- Clinical application Isoenzymes

May Know:

- Enzyme Kinetics, K_m and its significance

8. Metabolism of Carbohydrates:

Must Know:

- Ingestion of Dietary Carbohydrates and their importance
- Digestion and absorption of carbohydrates
- Transport and Uptake of Glucose
- Metabolic fates of Glucose in well fed and Fasting conditions

Should Know:

- Glycolysis
- Citric acid cycle
- Gluconeogenesis
- HMP shunt and its significance
- Glycogenesis and Glycogenolysis
- Regulation of Glycogenesis and Glycogenolysis
- Glycogen Storage diseases
- Lactate Metabolism: Cori's cycle
- Blood Glucose level and its regulation
- Biochemical aspects of Diabetes mellitus
- GTT
- Glycosuria

May Know:

- Rappaport Leubering cycle and its significance
- Uronic acid pathway significance and related Inborn error

- Metabolism of Galactose and Galactosemia
- Metabolism of Fructose and Fructosuria
- Mucopolysaccharoidosis

9. Metabolism of Lipids:

Must Know:

- Ingestion of Dietary Lipids and their importance
- Digestion, absorption, transport and uptake of dietary Lipids
- Lipolysis: Mobilization of depot Fat
- β oxidation of saturated (even and odd carbons) Fatty acids
- Role of Carnitine in the oxidation of long chain fatty acids
- Formation and utilization of Ketone bodies
- Regulation of Ketogenesis and Ketosis
- Cholesterol Metabolism – Biosynthesis and Regulation
- Blood level, transport of Cholesterol and Hypercholesterolemia
- Degradation of cholesterol and its regulation

Should Know:

- De Novo Biosynthesis of fatty acids and its regulation
- Lipoprotein Metabolism
- Dyslipidemias
- Fatty liver and lipotropic factors
- Adipose tissue metabolism
- Biochemical changes in Atherosclerosis

May Know:

- PUFA Biosynthesis and Oxidation
- Metabolism of Triglycerides and Phospholipids
- Alpha and Omega Oxidation of Fatty acids
- Fatty acid chain elongation-mitochondrial and Microsomal
- Inborn Errors of Lipid Metabolism
- Alcohol metabolism

10. Metabolism of Protein and Amino acids :

Must Know:

- Ingestion of Dietary Proteins and its importance.
- Digestion and absorption of dietary proteins

- Formation and Fate of Ammonia – Urea Cycle
- Disorders of Urea cycle

Should Know:

- Amino acid pool and Fates of amino acids in the body
 - Deamination,
 - Transamination
 - Transdeamination
 - Transamidination
 - Transmethylation
 - Decarboxylation
- Metabolism of Glycine and its disorders
- Metabolism of aromatic amino acids and their disorders

May Know:

- Synthesis of Glutamate, Glutamine
- Metabolism of Sulphur containing amino acids and their disorders
- Creatine Phosphate and its Role
- One carbon Metabolism

11. Nucleoprotein Metabolism:

Must Know:

- Fate of dietary Nucleoproteins
- Sources for Biosynthesis of Purine and Pyrimidine Nucleotides

Should Know:

- Salvage pathway
- Breakdown of Purine Nucleotides
- Gout and Lesch – Nyhan Syndrome
- Biosynthesis and end products of Pyrimidine breakdown
- Adenosine Deficiency

12. Biochemical Genetics:

Must Know:

- Structure and Functions of DNA and RNAs
- Genetic Code
- Replication of DNA

- Transcription, Translation – Protein biosynthesis /Gene Expression.

Should Know:

- Inhibitors of Protein biosynthesis
- Post Transcriptional and post Translational modifications
- Molecular mechanism of gene expression and regulation-Lac operon model
- Gene Mutations- types, causes and its consequences

May Know:

- Transposons and Retroposons

13.Genetic Engineering

Must Know:

- Recombinant DNA its technology and tools
 - Restriction Endonucleases
 - Vector, Plasmid and Cosmid

Should Know:

- RFLP, SNPS
- Reverse Transcriptase, c DNA
- Polymerase Chain Reaction and its application
- Applications of Recombinant DNA technology

May Know:

- Chimeric molecule and Gene Library
- DNA sequencing
- Gene therapy

14.Vitamins

Must Know:

- Vitamins :Definition , General Nature
- Classification
- Sources, active forms, metabolic role, daily requirement deficiency manifestations and Hypervitaminosis of:

- **Fat soluble Vitamins:**
 - Vitamin A, D, E and K
- **Water soluble Vitamins:**
 - Thiamine, Riboflavin, Niacin, Folic acid, Vitamin, B12, Pyridoxine, Biotin Pantothenic acid and Vitamin.

15, Biological Oxidation:

Must Know:

- General concept of oxidation and reduction reactions
- Role of enzymes and coenzymes in biological oxidation reactions
- Electron transport chain complexes and its inhibitors
- Oxidative phosphorylation mechanism theories and its inhibitors
- Role of Uncouples
- High energy compounds and Substrate level phosphorylation

May Know:

- Disorders associated to defective Mitochondrion's
- Shuttle Systems and their significance

16. Mineral metabolism

Must Know:

- Minerals-Definition ,Classification and Properties
- **Macro Minerals**-Sources, RDA, Biochemical functions, distribution, and their associated Disorders:
 - Calcium
 - Phosphorus
 - Sodium
 - Potassium
 - Chlorine
- **Trace elements:** Sources, RDA, Biochemical functions, distribution and associated Disorders
 - Iron
 - Iodine
 - Zinc
 - Fluoride
 - Selenium
 - Copper

- Magnesium
- Sulphur
- Cobalt
- Manganese

17.Nutrition

Must Know:

- Nutrition Goal and its importance
- Food nutrients and their role
- Food Groups and Sources
- Energy requirement-Calorific value of food
- Role of dietary fibers
- Biological Value of Protein

Should Know:

- Respiratory Quotient (RQ)
- Basal Metabolic Rate :Definition,Estimation,Factors affecting and Significance
- Specific Dynamic Action (SDA)/Thermogenic Effect of Food Substances
- Balanced diet : features and its significance
- RDA and dietary sources of nutrients
- Protein energy malnutrition (PEM) – Kwashiorkor, Marasmus
- Nitrogen Balance :Positive and Negative Nitrogen Balance
- Obesity :Causes and Consequences

18.Water, Electrolytes, Buffers and PH

Must Know:

- Human Body Water : Distribution and Role
- Body Electrolytes and their role
- Factors regulating Water and Electrolyte balance
- Water and Electrolyte imbalance :Causes ,Conditions and Consequences
- Analysis of Water and Electrolytes

Should Know:

- Dehydration: Types ,Features, Management

- Overhydration

19. Acid base balance and imbalance

Must Know:

- Blood pH
- Factors of Acid Base Homeostasis
- Role of Blood Buffers
- Respiratory and Renal mechanism to maintain Acid base balance
- Acidosis and Alkalosis
- ABG Analysis

20 Organ function tests:

Must Know:

- **Liver function Tests-**
- LFT: Classification and their interpretations:
- Standard LFTs: Determination of Proteins, Bilirubin, Prothrombin time, Alkaline Phosphatase, Glutamate Pyruvate Transaminase (ALT), Glutamate Oxaloacetate Transaminase (AST), Lactate Dehydrogenase.
- Hepatic markers for detection of types of hepatitis

- **Renal Function Tests –**
- Clearance Tests: Urea clearance test, Creatinine clearance test and their interpretations
- **Thyroid function tests-** classification and interpretations: T3, T4, TSH and Thyroxine binding globulin (TBG).
- **Gastric function Tests-** Intestinal Function Tests
- **Pancreatic Function Tests**
- **Cardiac Function Tests**

21. Immunology

Must Know

- Reticuloendothelial system
- Immunity Types
- Acquired immune response role of T & B lymphocytes

- Antigen presentation and induction of immune response
- Immunoglobulin structure and functions
- Humoral immune response

Should Know

- Fate of antigen antibody complex
- Cell mediated immune response delayed type hypersensitivity

May Know:

- Immunoregulation
- Autoimmunity tolerance
- HLA, disease association & transplantation
- Immunological techniques application in medicine

22.Detoxication mechanisms/Biotransformation of Xenobiotics

Must Know

- Phase I and Phase II Detoxication Reactions–
 - Oxidation Reactions
 - Reduction Reactions
 - Hydrolysis Reactions
 - Conjugation Reactions

Should Know

- Role of mixed function oxidase system (MFOS)
- Cytochrome P 450 as an integral part of MFOS
- Significance of Detoxification
- Consequences of defective Detoxification system and mechanism

23.Hormones

Must Know

- Definition, classification
- Mechanism of Steroid and Protein hormonal action.
- Role of Second messengers– cAMP, Ca⁺⁺ and Phosphatidyl Inositol
Pancreatic hormones.

Should Know

- Role of Insulin, Glucagon, Epinephrine and Norepinephrine.
- Anterior pituitary hormones chemistry mechanism of action,
- Hormones of the posterior pituitary hormones,
- Biosynthesis of steroid hormones in the foetoplacenta
- Thyroid Hormone
- Adrenal Hormones
- Calcitriol, Parathormone
- Endocrine Profiles

May Know

- Cell Signaling pathways

24.Integrated Metabolism and Biochemistry of Starvation

Must Know

- Interrelationship of Carbohydrate, Lipid, Protein and Nucleic acids metabolism.
- Metabolic adaptations of the body in well fed and Starvation condition
- Biochemical alterations in Starvation
- Metabolic status of Organs in well fed and Starvation

25.Molecular concepts of body defense and their application in medicine

Must Know

- Free radicals mode of generation and their consequences
- Antioxidant :Enzymatic and N-enzymatic antioxidants

26.Radioisotopes

Must Know

- Diagnostic & therapeutic applications of radioisotopes
- Radiation hazards

27.Biochemical basis of Cancer and Carcinogenesis

Must Know

- Etiology of Cancer

- Carcinogens / Mutagens and their mode of action
- Biochemical mechanisms for the activation of proto-oncogene to oncogene.

Should Know

- Tumor markers
- Apoptosis-p53 role
- Viral oncogenesis – Oncogenes and protooncogenes
- DNA viruses, RNA, viruses and Oncogenic products

28. Environmental biochemistry

Must Know

- Effects of cold and heat exposure
- Effect of physical and Biological agents on human Biochemistry
- Chemical Stress and its response
- Water and air pollutants
- Effect of Environs on human health and preventive measures

Practical Course Content

1. Principle and Use of Basic Instruments of Clinical Biochemistry

Laboratory

- Colorimeter
- Spectrophotometer
- Auto analyzers
- Electrophoresis
- Chromatography
- Electrolyte Analyzers/Flame photometry
- pH meter
- PCR
- ELISA
- RIA

2. Qualitative Experiment : Urine Analysis:

- Physical characteristics
- Tests for abnormal constituents of urine

3. Quantitate and interpret results of following Biochemical constituents from body fluids:

- Estimation of Blood Glucose
- Glucose Tolerance Test (GTT)
- Estimation of Blood Urea
- Estimation of serum Creatinine, Creatinine in Urine.
- Estimation of serum Total Proteins, Albumin and A:G ratio.
- Estimation of serum Total, Direct and Indirect Bilirubin.
- Estimation of serum Total Cholesterol.
- Estimation of serum Calcium.
- Estimation of serum Phosphorus (inorganic).
- Estimation of SGPT /ALT activity.
- Estimation of SGOT /AST activity.
- Estimation of serum Alkaline Phosphatase activity.
- Estimation of serum Amylase activity.
- Estimation of LDH activity.
- Estimation of serum Uric acid
- Analysis of Cerebrospinal Fluid.
- Analysis of Amniotic Fluid.

4. Demonstration Practicals:

- Immunodiffusion Techniques- RIA and ELISA
- ABG Analysis
- Electrolyte Analysis
- Serum Protein Electrophoresis
- DNA EXTRACTION AND GEL ELECTROPHORESIS
- Polymerase Chain Reaction (PCR)

5. Organ Function Tests

6. Case Studies

- Case Oriented Approaches to Metabolic Disorders/Organ Dysfunctions/Inborn Errors of Metabolism/Genetic Disorders/Nutritional Disorders/Immune Disorders

Distribution of Biochemistry Topics

Biochemistry Paper I

S.No	Name of the Topic	No of MCQ Alloted
01	Biochemistry of Cell	10
02	Amino acids and Proteins – Chemistry , Functions and Metabolism	40
03	Carbohydrates- Chemistry, Functions and Metabolism	40
04	Lipids -Chemistry ,Functions Functions and Metabolism	40
05	Metabolic Interrelations and Biochemistry of Starvation	10
06	Nutrition nutrients and malnutrition	20
07	Biological Oxidation	10
08	Vitamins	20
09	Hormones	10

Biochemistry Paper II

S.No	Name of the Topic	No of MCQ Alloted
01	Hemoglobin- Chemistry and Metabolism	10
02	Enzymes	20
03	Nucleic Acid Chemistry and metabolism	20
04	Biochemical Genetics/ Molecular biology	50
05	Minerals	20
06	Immunology	10
07	Detoxification	10
08	Biochemistry of Cancer	10
09	Organ Function Tests: G.F.T, KFT, LFT and TFT	10
10	Acid Base Balance	10
11	Water and Electrolyte Balance	10
12	Free Radicals and Antioxidant	10
13	Radioisotopes	05
14	Environmental Biochemistry	05

• **RECOMMENDED BOOKS**

International Author Books:

Text Books

1. Illustrated Biochemistry Lippincotts
2. Harper's Biochemistry, Ed. R.K. Murray

• **National Author Books**

1. Biochemistry by Vasudevan
2. Biochemistry by U Satyanarayan
3. Text Book of Biochemistry by Chatterjee & Rana Shinde
4. Text Book of Medical Biochemistry by S K Gupta

Reference Books

3. Textbook of Biochemistry with Clinical Correlations. Ed. Thomas M. Devlin, Wiley-Liss Publishers.
4. Tietz Textbook of Clinical Chemistry. Ed. Burtis and Ashwood.
5. Biochemistry. Ed. Donald Voet and Judith G. Voet. John Wiley
6. Immunology Ed. 5th Richard A. Goldsby, Thomas J Kindt, Barbara A Osborne, Janis Kuby.
7. Immunology Ed. 6th Ivan Roitt, Jonathan Brostoff, David Male.

- **Biochemistry Practical Manual**

The teaching, learning method employed includes:

- Didactic Lectures- Four hours/Week
- Practical Experimentation- Eight hours /Week
- Tutorials- One hour /Week
- Integrated teaching modules
- Seminars/Quiz
- Case based learning/Problem Based Learning

Number of Teaching Hours

Lecture	:	4 Hrs/week
Practicals	:	4 Hrs/week
Tutorials	:	1 Hr/week

BIOCHEMISTRY EXAMINATION PATTERN AND MARKS DISTRIBUTION

PROFESSIONAL THEORY EXAMINATION:

	Total 200 Marks
Biochemistry Paper I -	100 Marks
Biochemistry Paper II -	100 Marks

INTERNAL EXAMINATION PATTERN:

Examinations	Theory Paper	Practicals + Viva Voce
End Term Examination	100 Marks	75 Marks
Preliminary Examination	200 Marks	75 Marks

NATURE OF THEORY EXAM QUESTION PAPER

BIOCHEMISTRY THEORY PAPER	100 MARKS
Q. No.1. Multiple Choice Question (200- MCQs)	100 Marks

PRACTICAL EXAMINATION AND VIVA VOCE: Total 75 Marks

Spot Questions	20 Marks
Qualitative Experiment :	10 Marks
Quantitative Experiment :	20 Marks
OSPE :	20 Marks

	Final Exam	Internal Assessment	Total
Marks			
Theory Exam Marks	200 Marks	400 Marks	600
Reduced to Marks	75 Marks	75 Marks	150
Practical+ Viva Exam	75 Marks	175 Marks	250 Marks
Reduced to <u>Marks</u>	<hr/>	75 Marks	150
Marks	150 Marks	150 Marks	300

Note:

Students should score 50% marks separately in Theory and Practical to pass in the subject.