

Syllabus

Teaching hours – 160 hours

S1 Topic (Competency No) No.

1. Relevance of Biochemistry in Medicine Core:

Importance of Biochemistry in health and disease -

Examples of normal biochemical process

- Examples of biochemical derangements involved in disease development

- Examples of application of laboratory medicine in screening, diagnosis and prognosis of diseases

1 hr

(Orientation lecture)

2 Cell and organelles, Cell membrane, Transport across cell membranes (BI1.1)

2 hrs

Core:

Prerequisite: Concept of prokaryotic and eukaryotic cell

Cell organelles – Structure, Biochemical functions, Marker enzymes

Cell Membrane - Fluid mosaic model, composition, Fluidity of membrane

Transport across cell membranes with examples

• Passive transport – Diffusion and facilitated transport (ion channels)

• Active transport – Primary and Secondary

• Endocytosis and Exocytosis

Aquaporins

ABC family of transporters

Non core:

Cytoskeleton –

Structure and functions of microtubules, actin filaments, intermediate filaments

Intercellular communication

Separation of cell organelles

9 hrs

3 Enzymes (BI2.1, BI2.3, BI2.4, BI2.5, BI2.6, BI2.7)

Core:

Enzymes- Definition, General properties, IUBMB Classification.

Coenzymes and Cofactors

Mechanism of Enzyme action - Concept of activation energy, transition state, binding energy, active site; Substrate binding to active site - Koshlands Induced fit theory

Factors affecting enzyme activity

Effect of substrate concentration - Michaelis -Menton theory, Km value, Vmax and its significance (derivation not required)

Enzyme specificity

Enzyme inhibition - Competitive and Non-competitive inhibition with examples of clinical importance

Suicide inhibition

Enzymes as toxins – Eg. Snake venom phospholipase

Enzyme regulation by- Short term (Covalent modification, Zymogen activation,

Allosteric regulation, Feedback regulation) and long term regulation (Induction and repression)

Clinical Enzymology – Concept of plasma functional and non-functional enzymes

Diagnostic Importance of enzymes – LDH, CK, AST, ALT, ALP, GGT, Amylase, Lipase, G6PD, Cholinesterase, ACP, 5'nucleotidase

Isoenzymes – Definition, Diagnostic Importance of isoenzymes with examples.

Enzymes as Therapeutic agents

Enzymes used in diagnostic assays

Ribozymes

Non core:

Mechanisms of enzyme catalysis (List)

4 **Chemistry of Carbohydrates (BI3.1)**

3 hrs

Core:

Definition, Biomedical importance

Classification with examples

Monosaccharide derivatives – Uronic acids, aminosugars, Glycosides, Sorbitol, Mannitol and their Clinical significance.

Disaccharides, oligosaccharides -composition, importance

Polysaccharides –Homopolysaccharides – Composition and Importance of starch, glycogen, Dextran, Cellulose and Inulin.

Heteropolysaccharides – Mucopolysaccharides (Composition and function)

Concept of glycation and glycosylation

Importance of Glycoproteins

Non core:

Sialic acid – importance

Blood group substances

5 **Carbohydrate metabolism (BI3.2, BI3.3, BI3.4, BI3.5, BI3.6, BI3.7, BI3.9)**

14hrs

Core:

Digestion and absorption

Mechanism of absorption

Lactose intolerance

Glucose transporters

Insulin dependent and Insulin independent uptake of glucose by tissues

PATHWAYS – Significance, Site, reactions, key steps, energetics, regulation, inhibitors and associated disorders of -

- Glycolysis, Rapaport Leubering cycle and its significance
- Citric acid cycle, Amphibolic role, Anaplerotic reactions
- Gluconeogenesis, Cori's cycle
- Glycogenesis, Glycogenolysis, Glycogen storage disorders

Significance of HMP shunt pathway and uronic acid pathway

Glucose-6-Phosphate dehydrogenase deficiency

Galactosemia, Essential Fructosuria, Hereditary fructose intolerance Regulation of blood glucose levels in well fed condition and fasting/starvation

Non core:

Galactose and Fructose metabolism

Details of Pyruvate dehydrogenase (PDH) reaction

Essential pentosuria

6 Chemistry of lipids (BI4.1, BI11.24)

3 hrs

Core:

Definition, Modified Bloor's classification with examples.

Biomedical importance of lipids

Fatty acids - Definition, examples and importance of Essential fatty acids, Mono and Polyunsaturated fatty acids, n3 and n6 fatty acids, Trans-fatty acids.

Triacylglycerol – composition and importance

Phospholipids - Types, functions with clinical importance

Respiratory distress syndrome

Glycolipids – Types and importance

Cholesterol - structure and biological importance

Lipoproteins - Types and functions

Amphipathic lipids - Definition, examples and importance, Liposomes

Non core:

Fatty acids – nomenclature and different types of classification

Synthesis of lung surfactant

7. Lipid metabolism (BI4.2, BI4.3, BI4.4, BI4.6)

12 hrs

Core:

Digestion and Absorption

Steatorrhea

Biosynthesis and breakdown of triacylglycerol

PATHWAYS – Significance, Site, reactions, key steps, energetics, regulation, and associated disorders of -

- ⊙ Beta oxidation
- ⊙ Ketogenesis, ketolysis
- ⊙ Cholesterol biosynthesis upto mevalonate.

Other types of Oxidation of fatty acids and associated disorders

Lipoprotein metabolism Structure, Composition, Types, Functions, metabolism of

Chylomicrons, VLDL, LDL, HDL

Formation and functions of bile acids and bile salts

Fatty liver and lipotropic factors

Hyperlipoproteinemias

Biochemical basis of use of hypolipidemic drugs

Prostaglandins – types and biomedical importance

Non core:

Fatty acid synthase multienzyme complex

Outline of Fatty acid biosynthesis

Lipid Storage Disorders

8 **Chemistry of amino acids and Proteins (BI5.1, BI5.2)**

3 hrs

Core:

Prerequisite: Amino acids – Classification based on side chain properties, nutritional requirement

Classification of Amino acids based on metabolic fate

Standard and non-standard amino acids

Biologically important peptides

Proteins – Definition, Classification based on chemical nature and solubility, functions, nutritional value

Structural organisation of proteins (primary, secondary, super secondary structures/ motifs, domains, tertiary and quaternary structures)

Bonds stabilizing protein structure

Structure function relationship of proteins - haemoglobin, myoglobin, collagen and Insulin

Denaturation - definition, causes, properties of a denatured protein, significance.

Non core:

Isoelectric pH

Non-protein amino acids, Non-alpha amino acids, D-amino acids

9 **Protein and amino acid metabolism (BI5.3, BI5.4, BI5.5, BI11.17)**

13 hrs

Core:

Digestion and absorption and associated disorders

Amino acid pool

General reactions – Transamination, Transmethylation, Transdeamination, Deamination - Oxidative and nonoxidative and their significance.

Biogenic amines

Sources and fate of ammonia - Trapping, Transport and Disposal of ammonia, ammonia toxicity

Urea cycle and its disorders

Amino acid metabolism

Glycine – specialised products and their importance

Phenylalanine, Tyrosine – metabolic pathway, synthesis of catecholamines.

Pheochromocytoma

Other specialised products formed from tyrosine and their importance

Tryptophan- synthesis of serotonin and melatonin and their importance

Carcinoid syndrome

Sulphur containing amino acids – functions of cysteine, methionine synthesis of

SAM, SAH, Homocysteine

Formation of Nitric oxide and its importance

Inborn errors of metabolism – enzyme defects, clinical features, laboratory diagnosis and biochemical basis of management of – PKU, Tyrosinosis, Alkaptonuria, Albinism, Homocystinuria, Maple syrup urine disease (MSUD)
 Important functions/products from histidine, serine, Aspartate, Asparagine, glutamate, glutamine, serine, branched chain amino acids
 Polyamines - Examples and importance

Non core:

Techniques to separate and identify amino acids.

10 Plasma proteins (BI5.2)

3 hrs

Core:

Functions and clinical significance of plasma proteins - Albumin, α , β and γ globulins.
 Acute phase reactants - Positive and Negative (clinical significance)
 Biological Reference range of serum total protein, albumin, total globulin, C reactive protein
 Multiple Myeloma

Non core:

Separation and identification of plasma proteins by electrophoresis and precipitation reactions

11 Metabolism and homeostasis (BI6.1, BI3.8, BI4.5, BI4.7, BI3.10, BI11.17)

6 hrs

Core:

Metabolic processes taking place in specific organs in the body in fed, fasting and exercise states.
 Metabolic changes during starvation
 Adipose tissue – Hormones secreted from adipose tissue (adipokines – leptin, adiponectin) their functions and role in hunger and satiety.
 Diabetes mellitus – types, metabolic changes, complications.
 Guidelines for diagnosis of Diabetes mellitus
 Artificial sweeteners- list, use, metabolic effects(briefly) and concerns (to be discussed with in context of their use in Diabetes Mellitus).
 Lipid profile, Dyslipidemia
 Atherosclerosis – definition, role of lipids in atherogenesis (LDL, Oxidised LDL, Lp(a), Small dense LDL, HDL)
 Lab tests in Myocardial infarction

Non core:

Advanced Glycation End (AGEs) products

12 Biological Oxidation (BI6.6)

3 hrs

Core:

Prerequisite: Bioenergetics – Laws of thermodynamics, Free energy, Exergonic and endergonic reactions, Chemical Coupling Redox pair, Redox potential.
 High Energy Compounds – Definition, Classification, biological significance.
 Transport of reducing equivalents across mitochondria

Electron Transport Chain – Organization, components, flow of electrons.
 Oxidative Phosphorylation – Sites, mechanism (Chemiosmotic theory).
 Binding change mechanism of ATP synthesis by ATP synthase.
 Inhibitors of Electron Transport Chain and oxidative phosphorylation. Uncouplers and their significance.
 Brown adipose tissue metabolism.

Non core:

ATP-ADP cycle.
 Structure and organization of ATP synthase complex.
 Mitochondrial myopathies

13 Heme metabolism (BI6.11, BI6.12, BI5.2, BI11.17)

7 hrs

Core:

Heme –Outline of Synthesis, porphyrias
 Degradation of Heme, Bilirubin metabolism – synthesis, transport, conjugation, excretion
 Jaundice – definition, types, causes, lab diagnosis
 Congenital hyperbilirubinemias
 Hemoglobin – Adult, fetal and embryonic types
 Abnormal hemoglobins– carboxy, sulph, methHb.
 Hemoglobinopathies – molecular defects, pathophysiological changes in thalassemias and sickle cell anemia

Non core:

p50 of hemoglobins

14. Extracellular matrix (BI9.1, BI9.2)

4 hrs

Core:

Composition of ECM – Proteins (Composition and functions of Collagen, elastin, fibrillin, fibronectin, laminin) and Proteoglycans.
 Involvement of ECM components in health and disease. Eg.
 Osteogenesis Imperfecta, Ehler-Danlos syndrome etc

Non core:

Bone tissue– Concept of Bone turnover, factors affecting bone turnover, Peak bone mass, List of markers of bone formation and bone resorption.

15. Vitamins (BI6.5)

12 hrs

Core:

Prerequisite: Definition, difference between water and fat soluble vitamins

RDA, Sources, Metabolism, Biochemical functions, Deficiency manifestations,
 Hypervitaminoses of Fat soluble vitamins (A,D,E,K), Water soluble vitamins -
 Vitamin C, Folic acid, Vitamin B12, Thiamine, riboflavin, Niacin, Pyridoxine, Biotin,
 Pantothenic acid
 Antivitamins

Non core:

Vitamins

Lipoic acid

16 **Minerals (BI6.9, BI6.10)** 8 hrs

Core:

Major elements and trace elements

Sources, RDA, absorption and transport, Homeostasis, Functions, Biological reference range, disorders associated with – Calcium, phosphorus, Iron

Functions and disorders associated with - Copper, Zinc, Selenium, Fluoride, Iodine, Magnesium, Molybdenum.

17 **Chemistry of Nucleic acids (BI7.1)** 2 hrs

Core:

Prerequisite: Nitrogenous bases: Purines and Pyrimidines (Major, Minor, Free Bases);

Nucleosides and Nucleotides – Structure, examples, Importance

Nucleoside derivatives: NMP, NDP, NTP cAMP, SAM, PAPS, UDP sugars etc

Synthetic Nucleotide Analogues and their application

Structure and function of DNA (B-DNA)

Structural organization of DNA to form chromatin (Primary and Secondary)

Types of RNA (hnRNA, mRNA, rRNA, tRNA, snRNA) with structure and functions

microRNA (miRNA) and small interfering RNA (siRNA) and their applications in medicine

Non core:

Different types of DNA

18 **Nucleotide metabolism (BI6.2, BI6.3, BI6.4)** 4 hrs

Core:

Prerequisite: Sources of atoms of Purine and pyrimidine ring

Salvage pathways of Purine and pyrimidine synthesis

Catabolism of Purines, Uric acid and its importance

Etiology, manifestations and biochemical basis of clinical manifestations of – Gout,

LeschNyhan syndrome,

Non core:

SCID, Oroticaciduria

Diagnostic importance of Adenosine deaminase

19 **Molecular Biology (BI7.1, BI7.2, BI7.3, BI9.3)** 11 hrs

Core:

Concept of Genomics, proteomics and metabolomics

DNA Metabolism

Cell cycle

DNA replication - prokaryotic and eukaryotic replication, requirements, process, inhibitors

Telomere, Telomerase and its importance

DNA repair mechanisms

Diseases associated with DNA repair – Eg. Xeroderma Pigmentosum

Mutations, causes, types of mutation, Consequences with examples

RNA Metabolism

Transcription process

Transcriptional units, promoter regions, RNA polymerases in prokaryotes and eukaryotes

Differences between prokaryotic and Eukaryotic transcription

Inhibitors of transcription process

Post transcriptional modifications of all types of RNA

Protein Biosynthesis

Genetic Code and its characteristics

Requirements and activation of amino acids

Translation in Eukaryotes

Inhibitors of Translation

Post translational modifications

Regulation of Gene expression

Gene, introns, exons, cistron

Regulation of gene expression in prokaryotes with illustration of Lac Operon

Regulation of gene expression in eukaryotes – Role of enhancers, repressors, DNA regulatory elements, gene amplification, gene rearrangement, RNA processing, RNA editing, mRNA stability.

Non core:

Role of transcriptional activators and coregulators

Protein folding – Role of Chaperones and Heat shock proteins, Alzheimers disease, Prion diseases

Protein targeting and sorting with associated disorders Eg, I cell disease

Protein motifs in DNA regulatory proteins

Chromatin remodeling in regulation

Epigenetics

20. Molecular biology techniques and Gene therapy (BI7.4)

4 hrs

Core:

Recombinant DNA technology, DNA cloning - process and application

PCR technique and its application

Blotting techniques

Concept, types and application of gene therapy.

DNA Polymorphism, SNP, VNTR, RFLP

DNA genomic and cDNA libraries

DNA Probes

DNA Microarrays

Overview of Human Genome Project HGP

21 Biochemistry of Cancer (BI10.1, BI10.2)

5 hrs

Core:

Cell cycle, regulation, abnormal cell growth, programmed cell death (apoptosis)
 Cell signaling (action of hormones and growth factors) – Cell surface receptors - G protein coupled signaling, catalytic receptor signaling, steroid receptor signaling.
 Mutagens and carcinogens: Definitions, examples and their actions in carcinogenesis
 Protooncogenes and their activation, oncogenes, tumour suppressor genes and their role in development of cancer
 Oncogenic viruses (HPV and cervical cancer)
 Growth factors and their receptors
 Tumour markers and their importance in diagnosis and prognosis of cancer
 Biochemical basis of cancer therapy – alkylating agents, antimetabolites, topoisomerase inhibitors, antibiotics, hormones, receptor blockers, radiotherapy etc
 Monoclonal antibodies and their application

Non core:

Hybridoma technology
 Estrogen and progesterone receptors and their clinical importance in breast cancer

22 Immunology (BI10.3, BI10.4, BI10.5)

1 hr

Core:

Cellular and humoral components of immune system
 Immunoglobulins – Classes, structure function relationship
 Innate and adaptive immune responses, self/non-self-recognition
 Role of T-helper cells in immune responses
 Ig class switching
 Concept of Immune tolerance and Autoimmunity
 Antigens and concepts in vaccine development – types of vaccines, immunological basis of vaccine development, recombinant DNA technology in vaccine development.

Non core: Hypersensitivity reactions

Concept of graft rejection
 Phases of vaccine development.

23. Nutrition and dietetics (BI8.1, BI8.2, BI8.3, BI8.4, BI8.5, BI11.17, BI11.23, BI11.24)

7 hrs

Core:

Energy content of food items
 BMR – Definition, Normal values, Factors affecting and biomedical importance
 SDA – Definition and significance (Thermogenic effect of food)
 Nitrogen balance
 Balanced diet – definition, composition
 Dietary fibers – definition, examples, importance
 Glycemic index – definition, calculation, importance
 Nutritional importance of Carbohydrates, Lipids, Proteins, Vitamins and minerals, commonly used food items including fruits and vegetables.
 Nutritional indices
 Calculation of calorie requirement

Dietary advice for optimal health in childhood and adults, special conditions like diabetes mellitus, coronary artery disease, pregnancy.

Types, causes and effects of Protein energy malnutrition

Obesity – Definition, BMI, types, causes, role of GI peptides and adipokines in obesity, associated health risks (eg., metabolic syndrome)

24 Organ function tests (BI6.13, BI6.14, BI6.15, BI11.17)

11 hrs

Core:

Functions of Liver, Kidney, Thyroid and adrenals.

Liver Function Tests: Tests based on Synthetic, Excretory, and Role of enzymes in hepatic dysfunction

Renal Function tests – Tests to assess glomerular and tubular functions

Mechanism of action of Group I and Group II hormones

Thyroid function tests

Adrenal function tests

Non core:

Lab tests for evaluation of Infertility.

25 Acid base balance (BI6.7, BI6.8, BI11.17)

4 hrs

Core:

Prerequisite: Concept of Acids, Bases and buffers, HH Equation and its application

Regulation of pH of blood by buffers, respiratory and renal mechanisms

Anion gap and its significance

Acidosis and alkalosis (metabolic and respiratory) – causes, compensatory mechanisms and lab findings

26 Water and electrolyte balance (BI6.7)

3 hrs

Core:

Distribution of water and electrolytes in ICF and ECF

Osmolality of ECF

Regulation of water and electrolyte balance

Disorders of electrolyte imbalance – causes and clinical features of Hyperkalemia,

Hypokalemia, Hypernatremia, Hyponatremia

Dehydration

27 Free Radicals and Antioxidants (BI7.6, BI7.7)

3 hrs

Core:

Free radicals, Reactive oxygen species (ROS), Reactive nitrogen species (RNS)

Damaging effects of ROS on biomolecules, lipid peroxidation

Anti-oxidant defence system of our body – enzymes, vitamins, metabolites as antioxidants

Role of oxidative stress in atherosclerosis, diabetes mellitus and cancer

Non core:

Fenton and Haber Weiss reactions

28 Xenobiotics and Detoxification (BI7.5)

1 hr

Core:

Xenobiotics and disease caused. Biotransformation

Phase –I reactions

Oxidation

Hydroxylation

Cytochrome P450

Phase-II reactions

Conjugation reactions-Glucuronic acid, Glutathione, Glycine

Non core:

Other detoxification reactions reduction, hydrolysis, Acetylation, Methylation and reduction

29 **Clinical chemistry (BI11.16)**

2 hrs

Core:

Basic concepts of clinical chemistry laboratory

Automation - advantages

Quality control concepts (Internal and external quality control, precision, accuracy)

Specimen collection and Common Preanalytical errors

Biological reference intervals

Critical alerts

Ethics in Laboratory Medicine

Note:

1. Students are expected to familiarize by themselves the contents mentioned as prerequisite (in italics)