

Syllabus

of

B.Sc. (Honours) Biochemistry

Under

Choice Based Credit System

**Kazi Najrul University
Asansol, Burdwan
West Bengal**

Structure of B.Sc. (Hons) Biochemistry under CBCS

Core Course

C-I: Molecules of Life

C-II: Cell Biology

C-III: Proteins

C-IV: Enzymes

C-V: Metabolism of Carbohydrates and Lipids

C-VI: Membrane Biology and Bioenergetics

C-VII: Metabolism of Amino Acids and Nucleotides

C-VIII: Human Physiology

C-IX: Gene Organization, Replication and Repair

C-X: Hormone: Biochemistry and Function

C-XI: Concepts in Genetics

C-XII: Gene Expression and Regulation

C-XIII: Genetic Engineering and Biotechnology

C-XIV: Immunology

Detailed Syllabus for the Core Course Biochemistry Honours

SEMESTER - I

Core course-I (Theory):

MOLECULES OF LIFE (THEORY)

CREDITS: 4 (Marks - 50)

The foundations of biochemistry

Cellular and chemical foundations of life

Water

Unique properties, weak interactions in aqueous systems, ionization of water, buffers, water as a reactant and fitness of the aqueous environment.

Carbohydrates and glycobiology

Monosaccharides - structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives, oxidation of sugars. Formation of disaccharides, reducing and nonreducing disaccharides. Polysaccharides – homo- and heteropolysaccharides, structural and storage polysaccharides. Structure and role of proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides). Carbohydrates as informational molecules, working with carbohydrates

Lipids

Building blocks of lipids - fatty acids, glycerol, ceramide. Storage lipids - triacyl glycerol and waxes
Structural lipids in membranes – glycerophospholipids, galactolipids and sulpholipids, sphingolipids and sterols, structure, distribution and role of membrane lipids. Plant sterols. Lipids as signals, cofactors and pigments

Amino acids

Structure and classification, physical, chemical and optical properties of amino acids

Nucleic acids

Nucleotides - structure and properties. Nucleic acid structure – Watson-Crick model of DNA. Structure of major species of RNA - mRNA, tRNA and rRNA. Nucleic acid chemistry - UV absorption, effect of acid and alkali on DNA. Other functions of nucleotides - source of energy, component of coenzymes, second messengers.

Vitamins

Structure and active forms of water soluble and fat soluble vitamins, deficiency diseases and symptoms, hypervitaminosis

Core course -I (Practical):

MOLECULES OF LIFE (PRACTICALS)

CREDIT : 2 (Marks 50)

- 1.Safety measures in laboratories.
- 2.Preparation of buffers.
- 3.Determination of pKa of acetic acid and glycine (pH metric titration).
- 4.Qualitative tests for carbohydrates, lipids, amino acids, proteins and nucleic acids.
- 5.Separation of amino acids/ sugars/ bases by thin layer chromatography.
- 6.Estimation of vitamin C (Iodimetric method).

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13: 978-1-4641-0962-1 /ISBN:10:1-4292-3414-8
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN:978-0-470-28173-4.

Core course -II (Theory):

CELL BIOLOGY (THEORY)

CREDITS: 4 (Marks 50)

Introduction to cell biology

Prokaryotic (archaea and eubacteria) and eukaryotic cell (animal and plant cells), cells as experimental models.

Tools of cell biology

Light microscopy, phase contrast microscopy, fluorescence microscopy, confocal microscopy, electron microscopy, FACS. Centrifugation for subcellular fractionation.

Structure of different cell organelles

Structure of nuclear envelope, nuclear pore complex. ER structure. Organization of Golgi. Lysosome. Structure and functions of mitochondria, chloroplasts and peroxisomes. Zellweger syndrome.

Protein trafficking

Selective transport of proteins to and from the nucleus. Regulation of nuclear protein import and export. Targeting proteins to ER, smooth ER and lipid synthesis. Export of proteins and lipids from ER and into ER. Lipid and polysaccharide metabolism in Golgi. Protein sorting and export from Golgi. Mechanism of vesicular transport, cargo selection, coat proteins and vesicle budding, vesicle fusion. Protein import and mitochondrial assembly, protein export from mitochondrial matrix. Import and sorting of chloroplast proteins.

Cytoskeletal proteins

Structure and organization of actin filaments. Treadmilling and role of ATP in microfilament polymerization, organization of actin filaments. Non-muscle myosin. Intermediate filament proteins, assembly and intracellular organization. Assembly, organization and movement of cilia and flagella.

Cell wall and extracellular matrix

Prokaryotic and eukaryotic cell wall, cell matrix proteins. Cell-matrix interactions and cell-cell interactions. Adherence junctions, tight junctions, gap junctions, desmosomes, hemidesmosomes, focal adhesions and plasmodesmata.

Cell cycle, cell death and cell renewal

Eukaryotic cell cycle, restriction point, and checkpoints. Cell division. Apoptosis and necrosis - brief outline. Salient features of a transformed cell.

Core course-II (Practical):

CELL BIOLOGY (PRACTICAL)

CREDITS: 2 (Marks 50)

1. Visualization of animal and plant cell by methylene blue.
2. Identification of different stages of mitosis in onion root tip.
3. Identification of different stages of meiosis in grasshopper testis / onion flower bud.
4. Visualization of nuclear fraction by acetocarmine stain.

SUGGESTED READINGS

1. The Cell: A Molecular Approach (2009) 5th ed., Cooper, G.M. and Hausman, R.E., ASM Press & Sunderland (Washington DC), Sinauer Associates, MA, ISBN:978-0-87893-300-6.
2. Molecular Cell Biology (2012) 7th ed., Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J., W.H. Freeman & Company (New York), ISBN:13:978-1-4641-0981-2 / ISBN:10: 1-4641-0981-8.
3. Molecular Biology of the Cell (2008) 5th ed., Alberts, B., Johnson, A., Lewis, J., and Enlarge, M., Garland Science (Princeton), ISBN:0-8153-1619-4 / ISBN:0-8153-1620-8.

SEMESTER - II

Core course-III (Theory):

PROTEINS (THEORY)

CREDITS: 4 (Marks 50)

Introduction to amino acids, peptides and proteins

Amino acids and their properties - hydrophobic, polar and charged. Biologically important peptides - hormones, antibiotics and growth factors. Multimeric proteins, conjugated proteins and metallo proteins. Diversity of function

Extraction of proteins for downstream processing

Solubilization of proteins from their cellular and extracellular locations. Use of simple grinding methods, homogenization, ultrasonication, French press and centrifugation.

Separation techniques

Ammonium sulphate fractionation, solvent fractionation, dialysis and lyophilization. Ionexchange chromatography, molecular sieve chromatography, hydrophobic interaction/reverse phase chromatography, affinity chromatography, HPLC and FPLC

Characterization of proteins

Determination of purity, molecular weight, extinction coefficient and sedimentation coefficient, IEF, SDS-PAGE and 2-D electrophoresis.

Covalent structure of proteins

Organization of protein structure into primary, secondary, tertiary and quaternary structures. N-terminal and C-terminal amino acid analysis. Sequencing techniques - Edman degradation. Generation of overlap peptides using different enzymes and chemical reagents. Disulfide bonds and their location. Mass spectrometric analysis, tandem MS. Solid phase peptide synthesis

Three dimensional structures of proteins

Nature of stabilizing bonds - covalent and non covalent. Importance of primary structure in folding. The peptide bond - bond lengths and configuration. Dihedral angles psi and phi. Helices, sheets and turns. Ramachandran map. Techniques used in studying 3-D structures - X-ray diffraction and NMR. Motifs and domains. Tertiary and quaternary structures. Structures of myoglobin and haemoglobin

Protein folding and conformational diseases

Denaturation and renaturation of Ribonuclease A. Introduction to thermodynamics of folding and molten globule. Assisted folding by molecular chaperones, chaperonins and PDI. Defects in protein folding. Diseases - Alzheimer's and Prion based.

Introduction to protein structure databases

Protein sequence and structure databases (PDB). Use of sequence and domain information. Viewing protein structures using *in silico* tools.

Myoglobin and haemoglobin

Oxygen binding curves, influence of 2,3-BPG, CO₂ and Cl⁻. Hill plot. Cooperativity between subunits and models to explain the phenomena - concerted and sequential models. Haemoglobin disorders.

Specialized proteins - antibodies and actin-myosin motors

Antibody structure and binding to antigens. ATP activated actin - myosin contractions.

Membrane proteins

Integral and membrane associated proteins. Hydrophathy plots to predict transmembrane domains. Significance of membrane proteins - bacteriorhodopsin.

Core course-III (Practical):

PROTEINS (PRACTICAL)

CREDIT: 2 (Marks 50)

1. Estimation of proteins using UV absorbance and Biuret method.
2. Microassay of proteins using Lowry/Bradford method.
3. Isoelectric pH of casein.
4. Ammonium sulphate fractionation of serum proteins.
5. Separation of albumin from serum using anion-exchange chromatography.
6. SDS-PAGE analysis of proteins.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13: 978-1-4641-0962-1 / ISBN: 10: 1-4292-3414-8.
2. Physical Biochemistry (2009) 2nd ed., Sheehan, D., Wiley-Blackwell (West Sussex), ISBN: 9780470856024 / ISBN: 9780470856031.

3.The Tools of Biochemistry (1977; Reprint 2011) Cooper, T.G., Wiley India Pvt. Ltd. (New Delhi), ISBN: 978-81-265-3016-8.

CORE COURSE-IV (Theory):

ENZYMES (THEORY)

CREDITS: 4 (Marks 50)

Introduction to enzymes

Nature of enzymes - protein and non-protein (ribozyme). Cofactor and prosthetic group, apoenzyme, holoenzyme. IUBMB classification of enzymes./

Features of enzyme catalysis

Factors affecting the rate of chemical reactions, collision theory, activation energy and transition state theory, catalysis, reaction rates and thermodynamics of reaction. Catalytic power and specificity of enzymes (concept of active site), Fischer's lock and key hypothesis, Koshland's induced fit hypothesis.

Enzyme kinetics

Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant - monosubstrate reactions. Michaelis-Menten equation, Lineweaver-Burk plot, Eadie-Hofstee and Hanes plot. K_m and V_{max} , K_{cat} and turnover number. Effect of pH, temperature and metal ions on the activity of enzyme.

Bisubstrate reactions

Types of bi bi reactions (sequential – ordered and random, ping pong reactions). Differentiating bi substrate mechanisms (diagnostic plots, isotope exchange).

Enzyme inhibition

Reversible inhibition (competitive, uncompetitive, non-competitive, mixed and substrate). Mechanism based inhibitors - antibiotics as inhibitors.

Mechanism of action of enzymes

General features - proximity and orientation, strain and distortion, acid base and covalent catalysis (chymotrypsin, lysozyme). Metal activated enzymes and metalloenzymes, transition state analogues.

Regulation of enzyme activity

Control of activities of single enzymes (end product inhibition) and metabolic pathways, feedback inhibition (aspartate transcarbamoylase), reversible covalent modification phosphorylation (glycogen phosphorylase). Proteolytic cleavage- zymogen. Multienzyme complex as regulatory enzymes.

Occurrence and isolation, phylogenetic distribution and properties (pyruvate dehydrogenase, fatty acyl synthase) Isoenzymes - properties and physiological significance (lactate dehydrogenase).

Involvement of coenzymes in enzyme catalysed reactions

TPP, FAD, NAD, pyridoxal phosphate, biotin, coenzyme A, tetrahydrofolate, lipoic acid.

Applications of enzymes

Application of enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases), enzyme immunoassay (HRPO), enzyme therapy (Streptokinase). Immobilized enzymes.

Core course – IV (Practical):
ENZYMES (PRACTICAL)
CREDIT 2 (Marks 50)

1. Partial purification of acid phosphatase from germinating mung bean.
2. Assay of enzyme activity and specific activity, e.g. acid phosphatase.
3. Effect of pH on enzyme activity
4. Determination of K_m and V_{max} using Lineweaver-Burk graph.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13: 978-1-4641-0962-1 / ISBN:10:1-4292-3414-8.
2. Biochemistry (2011) 4th ed., Donald, V. and Judith G.V., John Wiley & Sons Asia Pvt. Ltd. (New Jersey), ISBN:978-1180-25024.
3. Fundamentals of Enzymology (1999) 3rd ed., Nicholas C.P. and Lewis S., Oxford University Press Inc. (New York), ISBN:0 19 850229 X.

Interdisciplinary/Generic Elective (Any four) from other departments

(Four papers are to be taken and each paper will be of 6 credits).

Detailed Syllabus for Biochemistry as GE subject

SEMESTER – I

GE-1 :

BIOCHEMISTRY OF CELL (THEORY)

CREDITS: 4 (Marks 50)

Biomolecules in their cellular environment

The cellular basis of life. Cellular structures – prokaryotes and eukaryotes. Chemical principles in biomolecular structure. Major classes of biomolecules. Role of water in design of biomolecules.

Amino acids and peptides No. of Hours : 10

Types of amino acids and their chemistry, derivatives of amino acids and their biological role.

Introduction to biologically important peptides.

Sugars and polysaccharides No. of Hours : 10

Basic chemistry of sugars, optical activity. Disaccharides, trisaccharides and polysaccharides - their distribution and biological role.

Nucleosides, nucleotides and nucleic acids

Structures and chemistry, DNA structures and their importance, different types of RNA. Unusual DNA structures, other functions of nucleotides.

Lipids

Various classes of lipids and their distribution, storage lipids, structural lipids in membranes, lipids as signals, cofactors and pigments.

Vitamins, coenzymes and metal ions

Occurrence and nutritional role. Coenzymes and their role in metabolism. Metal ion containing biomolecules - heme, porphyrins and cyanocobalamin; their biological significance.

Signalling molecules

Second messengers - cAMP, cGMP, IP₃, diacyl glycerol, Ca₂₊, NO. Brief account of their importance and role in signalling and signal transduction.

GE-I (Practical):

BIOCHEMISTRY OF CELL (PRACTICALS)

CREDITS: 2 (Marks 50)

1. General safety procedures in a laboratory. Use of auto pipettes. Making solutions and buffer preparation - acetate and tris buffers.
2. Qualitative tests for biomolecules - carbohydrates, lipids, amino acids, proteins, bases and nucleic acids.
3. Separation of amino acids by paper chromatography.
4. Separation of sugars/bases by TLC and their identification.
5. Estimation of ascorbic acid in fruit juices.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13; 978-1-4641-0962-1 / ISBN:10-14641-0962-1.
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN:978-0-470-28173

SEMESTER – II

GE- II (Theory) : PROTEINS AND ENZYMES (THEORY)

CREDITS: 4 (Marks 50)

Introduction to proteins

Polypeptides and proteins. Subunit structures, conjugated proteins, diversity of function.

Techniques to isolate and analyze proteins- salt fractionation, ion-exchange chromatography, gel permeation, HPLC, SDS-PAGE, IEF. Protein primary structure - sequencing by Edman degradation, use of enzymes and chemical reagents to obtain overlap peptides. Synthesis of peptides using Merrifield method.

Introduction to protein three-dimensional structures

Secondary structure- helices and sheets, Ramachandran maps. Nature of non-covalent bonds and covalent bonds in protein folding. Tertiary and quaternary structures.

Myoglobin and haemoglobin - structure and function

Oxygen binding curves, cooperativity models for haemoglobin.

Introduction to enzyme catalysis

Features of enzyme catalysis, superior catalytic power. General mechanisms of catalysis. Nomenclature.

Enzyme kinetics

Principles of reaction rates, order of reactions and equilibrium constants. Derivation of Michaelis-Menten equation. Significance of K_m and V_{max} . Catalytic efficiency parameters. Competitive and mixed inhibitions. Kinetics and diagnostic plots. Types of irreversible inhibitors.

Mechanisms of enzyme action and regulation

Mechanism of action of chymotrypsin. Inhibitors of enzymes - antibiotics. Regulation of enzyme activity and its importance - aspartate transcarbamoylase.

Enzymes in medicine and industry

Enzymes used in clinical biochemistry as reagents, diagnostics and therapy. Role of immobilized enzymes in industry.

GE-II (Practicals) : PROTEINS AND ENZYMES (PRACTICALS) CREDITS: 2 (Marks 50)

1. Protein estimation by UV absorbance and Biuret method.
2. Ammonium sulphate fractionation of crude homogenate from germinated mung bean.
3. Setting up assay for acid phosphatase and activity measurements of the ammonium sulphate fractions (progress curve and effect of pH).
4. Determination of K_m and V_{max} of enzyme enriched fraction.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13; 978-1-4641-0962-1 / ISBN:10-14641-0962-1.

2. Fundamentals of Enzymology (1999) 3rd ed., Price, N.C and Stevens, L., Oxford University Press Inc., (New York), ISBN:13: 978-0-19-806439-8.

SEMESTER - III

GE-III : INTERMEDIARY METABOLISM (THEORY)

CREDITS: 4 (Marks 50)

Basic concepts and design of metabolism

The nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency.

Glycolysis and gluconeogenesis

Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis.

The citric acid cycle

Pyruvate dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway.

Oxidative phosphorylation

The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3-phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.

Photosynthesis, Calvin cycle and pentose phosphate pathway

The light reaction, chlorophyll, accessory pigments, reaction centres, two photo systems, generation of proton gradient and NADPH, Calvin cycle, synthesis of glucose, starch, sucrose, regulation, C₄ pathway. Pentose phosphate pathway, importance and regulation.

Glycogen metabolism

Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis.

Fatty acid synthesis and degradation

TAG as energy source, β oxidation of fatty acids in mitochondria and peroxisomes, ketone bodies. Biosynthesis of fatty acids - elongation and unsaturation of fatty acids. Regulation of fatty acid oxidation and synthesis.

Amino acid catabolism and anabolism

Protein degradation to amino acids, urea cycle, feeder pathways into TCA cycle. Nitrogen fixation, synthesis of non-essential amino acids.

Nucleotide metabolism

Biosynthesis - *de novo* and salvage pathways, regulation of nucleotide synthesis by feedback inhibition, degradation and excretion.

Integration of metabolism

Brief role of hormones - catecholamines, insulin, glucagon; metabolic shifts to provide fuel to brain during fasting and starvation, role of cortisol in signalling stress - increase in gluconeogenesis and muscle protein breakdown.

GE-III (Practical) :

INTERMEDIARY METABOLISM (PRACTICALS)

CREDITS: 2 (Marks 50)

1. Alcohol fermentation by yeast.
2. H₂S production, indole production and ammonia production by bacteria.
3. Urea estimation.
4. Nitrogen fixation by cyanobacteria.

SUGGESTED READINGS

1. Biochemistry (2012) 7th ed., Campbell, M.K. and Farrel, S.O. Brooks/Cole, Cengage Learning (Boston), ISBN: 13:978-1-111-42564-7.

SEMESTER – IV

GE-IV (Theory) :

GENE ORGANIZATION, EXPRESSION AND REGULATION (THEORY)

CREDITS: 4 (Marks 50)

Structure of genes and chromosomes

Definition of a gene, chromosomal organization of genes in viruses, bacteria and eukaryotes. Supercoiling of DNA.

Replication of genomes

General features of DNA replication, properties of prokaryotic and eukaryotic DNA polymerases. Replication of DNA and telomeres in linear chromosomes. Replication of RNA genomes.

Recombination of DNA

Homologous genetic recombination, Holliday model, proteins and enzymes mediating recombination.

Gene mutations and repair

Molecular basis of mutations, multiple repair systems, mismatch repair, base excision repair, nucleotide excision repair, direct repair and translesion DNA synthesis.

Transcription of genes

General features of gene transcription, prokaryotic and eukaryotic RNA polymerases, stages of transcription, initiation, elongation and termination. Inhibitors of transcription.

RNA processing

Processing of eukaryotic mRNA, splicing of introns, alternate splicing and editing, ribosomal and tRNA processing.

Protein synthesis

Features of the genetic code, amino acylation of tRNAs, structure and assembly of ribosomes; three stages of protein synthesis - initiation, elongation and termination. Inhibitors of protein synthesis.

Regulation of gene expression

Regulation of transcription in prokaryotes, concept of operons. Lac operon - control by negative and positive regulatory proteins, Trp operon - control by attenuation. Regulation of transcription in eukaryotes, regulatory sequences - enhancers, silencers response elements, nucleosome alterations, DNA-protein interactions and RNA interference.

GE- IV (Practicals) :

GENE ORGANIZATION, EXPRESSION AND REGULATION (PRACTICAL)

CREDITS: 2 (Marks 50)

1. Quantitative determination of DNA and RNA by absorbance at 260 nm and using A_{260}/A_{280} ratio to distinguish between them.
2. To study the viscosity of DNA solutions.
3. Isolation of chromosomal DNA from *E. coli*.
4. Isolation of total RNA from yeast cells / *E. coli*.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13; 978-1-4641-0962-1 / ISBN:10-14641-0962-1.

SEMESTER - V

GE-V (Theory):

FUNDAMENTALS OF CELL BIOLOGY AND IMMUNOLOGY

(THEORY)

CREDITS: 4 (Marks 50)

Cells and organelles

Prokaryotic and eukaryotic cells. Plasma membrane, the nucleus, intracellular membranes and organelles, mitochondria, chloroplast, endoplasmic reticulum, Golgi complex, lysosome, peroxisome, cytoskeleton, extracellular matrix, cell wall. Mitosis and meiosis.

Membrane structure and function

Composition of membranes, membrane lipids, membrane proteins, isolation and characterization. Integral, peripheral and lipid anchored protein. Transport across membranes, simple and facilitated diffusion, active transport.

Endoplasmic reticulum and Golgi complex

The two types of endoplasmic reticulum, rough and smooth. The Golgi complex. Role of Golgi in protein glycosylation and protein trafficking.

Signalling mechanisms, messengers and receptors

Chemical signals and cellular receptors. G-protein linked receptors, protein kinase associated receptors. Hormonal signalling, cell signals and apoptosis.

Cell cycle and its regulation

Overview of the cell cycle. Regulation of the cell cycle, cyclin dependent kinases.

Overview of the immune system

Self versus nonself. Humoral and cellular immunity. Innate and adaptive immunity. Cells of the immune system, primary and secondary lymphoid tissues and organs. Cellular and humoral responses.

Innate immunity

Defensins. Non-immunological barriers. Cells and soluble mediators of innate immunity. Acute phase proteins. Cytokines. Complement system.

Humoral B cell response

Structure of antibodies, types of immunoglobulins, generation of antibody diversity, B cell activation, theory of clonal selection, formation of plasma and memory cells; T-independent B-response; antigens, haptens carriers and adjuvants.

Cell mediated immunity

T-cell development, MHC locus. Structure, function and distribution of MHC glycoproteins. Antigen processing and presentation. Cell mediated immune responses by different T-cell sub populations. Hypersensitive reactions. Concept of autoimmunity.

GE-V (Practical) :

FUNDAMENTALS OF CELL BIOLOGY AND IMMUNOLOGY (PRACTICALS)

CREDITS: 2 (Marks 50)

1. Visualization of animal and plant cell by methylene blue.
2. Identification of different stages of mitosis in onion root tip.
3. Isolation of organelles by sub-cellular fractionation.
4. Determination of blood grouping

SUGGESTED READINGS

2. The World of the Cell (2009), 7th ed., Becker W.M., Kleinsmith, L.J., Hardin., J., Bertoni, and G.P., Pearson Benjamin Cummings (CA), ISBN: 978-0-321-55418-5.
3. Prescott, Harley, Klein's Microbiology (2008) 7th Ed., Willey, J.M., Sherwood, L.M., Woolverton, C.J. Mc Graw Hill International Edition (New York) ISBN: 978-007-126727.
4. Molecular Cell Biology (2013) 7th Ed., Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Scott, M.P., Macmillan International Edition (New York), ISBN:13: 978-1-4641-0981-2.
5. Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A., W.H. Freeman and Company (New York), ISBN:13: 978-0-7167-8590-3 / ISBN: 10:0-7617-8590-0.
6. Immunology: A Short Course (2009) 6th ed.,

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE) C-5 :
METABOLISM OF CARBOHYDRATES AND LIPIDS (THEORY)
SEMESTER - III**

Marks: 50

CREDITS: 4

Unit 1 Basic design of metabolism

Autotrophs, heterotrophs, metabolic pathways, catabolism, anabolism, ATP as energy currency, reducing power of the cell.

Unit 2 Glycolysis

Glycolysis - a universal pathway, reactions of glycolysis, fermentation, fates of pyruvate, feeder pathways for glycolysis, galactosemia.

Unit 3 Gluconeogenesis and pentose phosphate pathway

Synthesis of glucose from non-carbohydrate sources, reciprocal regulation of glycolysis and gluconeogenesis, pentose phosphate pathway and its importance.

Unit 4 Glycogen metabolism

Glycogenesis and glycogenolysis, regulation of glycogen metabolism, glycogen storage diseases.

Unit 5 Citric acid cycle

Production of acetyl CoA, reactions of citric acid cycle, anaplerotic reactions, amphibolic role, regulation of citric acid cycle, glyoxalate pathway, coordinated regulation of glyoxalate and citric acid pathways.

Unit 6 Synthesis of carbohydrates

Calvin cycle, regulation of calvin cycle, regulated synthesis of starch and sucrose, photorespiration, C₄ and CAM pathways, synthesis of cell wall polysaccharides, integration of carbohydrate metabolism in plant cell.

Unit 7 Fatty acid oxidation

Digestion, mobilisation and transport of cholesterol and triacyl glycerols, fatty acid transport to mitochondria, β oxidation of saturated, unsaturated, odd and even numbered and branched chain fatty acids, regulation of fatty acid oxidation, peroxisomal oxidation, ω oxidation, ketone bodies metabolism, ketoacidosis.

Unit 8 Fatty acid synthesis

Fatty acid synthase complex. Synthesis of saturated, unsaturated, odd and even chain fatty acids and regulation.

Unit 9 Biosynthesis of cholesterol, steroids and isoprenoids

Synthesis of prostaglandins, cholesterol, steroids and isoprenoids. Regulation of cholesterol synthesis.

Unit 10 Biosynthesis of membrane lipids

Synthesis of membrane phospholipids in prokaryotes and eukaryotes, respiratory distress syndrome, biosynthesis of triacylglycerol, biosynthesis of plasmalogens, sphingolipids and glycolipids, lipid storage diseases.

Unit 11 Starve-feed cycle

Well-fed state, early fasting state, fasting state, early re-fed state, energy requirements, reserves and caloric homeostasis, five phases of glucose homeostasis.

C-5 : METABOLISM OF CARBOHYDRATES AND LIPIDS (PRACTICALS) SEMESTER – III

Marks: 50

CREDITS: 2

1. Estimation of blood glucose (spectrophotometric/colorimetric method).
2. Sugar fermentation of microorganisms.
3. Assay of salivary amylase.
4. Isolation of lecithin from egg yolk, identification by TLC.
5. Isolation of cholesterol from egg yolk and its estimation.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New Jersey), ISBN:978-0-470-28173-4.
3. Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE) C-6 : MEMBRANE BIOLOGY AND BIOENERGETICS (THEORY) SEMESTER – III

Marks:50

CREDITS: 4

Unit 1 Introduction to biomembranes

Composition of biomembranes - prokaryotic, eukaryotic, subcellular membranes. Study of membrane proteins. Fluid mosaic model with experimental proof.

Unit 2 Membrane structures

Polymorphic structures of amphiphilic molecules in aqueous solutions - micelles and bilayers. Membrane asymmetry. Macro and micro domains in membranes. Membrane skeleton. RBC membrane architecture.

Unit 3 Membrane dynamics

Lateral, transverse and rotational motion of lipids and proteins. Transition studies of lipid bilayer. Membrane fluidity, factors affecting membrane fluidity.

Unit 4 Membrane transport

Thermodynamics of transport. Simple diffusion and facilitated diffusion. Passive transport-glucose transporter, anion transporter and porins. Primary and secondary active transporters. Na⁺-glucose symporter. ABC family of transporters. Group translocation. Ion channels - voltage-gated ion channels (Na⁺/K⁺ voltage-gated channel), ligand-gated ion channels (acetyl choline receptor), aquaporins, bacteriorhodopsin. Ionophores - valinomycin, gramicidin.

Unit 5 Introduction to bioenergetics

Laws of thermodynamics, state functions, equilibrium constant, coupled reactions, energy charge, ATP cycle, phosphorylation potential, phosphoryl group transfers. Chemical basis of high standard energy of

hydrolysis of ATP, other phosphorylated compounds and thioesters. Redox reactions, standard redox potentials. Universal electron carriers.

Unit 6 Oxidative phosphorylation

Mitochondria. Electron transport chain (ETC) - its organization and function. Inhibitors of ETC and uncouplers. Mitchell's chemiosmotic hypothesis. Proton motive force. F_0F_1 ATP synthase, structure and mechanism of ATP synthesis. Metabolite transporters in mitochondria. Regulation of oxidative phosphorylation. ROS production and antioxidant mechanisms. Thermogenesis. Alternative respiratory pathways in plants.

Unit 7 Photophosphorylation

General features of photophosphorylation, historical background, Hill reaction, photosynthetic pigments, light harvesting systems of plants and microbes and resonance energy transfer. Bacterial photophosphorylation in purple bacteria, green sulfur bacteria. Photophosphorylation in plants - structure of chloroplast, molecular architecture of Photosystem I and Photosystem II, Z-scheme of photosynthetic electron flow, oxygen evolving complex and action of herbicides. Cyclic photophosphorylation and its significance. Evolution of oxygenic photosynthesis.

C-6 : MEMBRANE BIOLOGY AND BIOENERGETICS (PRACTICALS)

SEMESTER - III

Marks:50

CREDITS: 2

1. Determination of CMC of detergents.
2. RBC ghost cell preparation and to study the effect of detergents on membranes.
3. Separation of photosynthetic pigments by TLC.
4. Study photosynthetic O_2 evolution in hydrilla plant.
5. Isolation of chloroplast from spinach leaves, estimation of chlorophyll and photosynthetic activity.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
2. Molecular Cell Biology (2013) 7th ed., Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Scott, M.P., W.H. Freeman & Company (New York), ISBN:13:978-1-4641-0981-2.
3. Biochemistry (2010) 4th ed., Garret, R. H. and Grisham, C.M., Cengage Learning (Boston), ISBN-13:978-0-495-11464-2.
4. Principles of Biochemistry (2008) 3rd ed., Voet, D.J., Voet, J.G. and Pratt, C.W., John Wiley & Sons, Inc. (New York), ISBN:13: 978-0470-23396-2

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
C-7 : METABOLISM OF AMINO ACIDS AND NUCLEOTIDES
(THEORY)
SEMESTER – III

Marks:50

CREDITS: 4

Unit 1 Overview of amino acid metabolism

Nitrogen cycle, incorporation of ammonia into biomolecules. Metabolic fates of amino groups. Digestion and absorption of dietary proteins. Protein calorie malnutrition - Kwashiorkar and Marasmus. Nitrogen balance, transamination, role of pyridoxal phosphate, glucose-alanine cycle, Krebs bicycle, urea cycle.

Unit 2 Catabolism of amino acids

Catabolic pathways of individual amino acids. Glucogenic and ketogenic amino acids. Metabolism of one carbon units. Disorders of amino acids metabolism, phenylketonuria, alkaptonuria, maple syrup urine disease.

Unit 3 Biosynthesis of amino acids

Overview of amino acid synthesis. Biosynthesis of amino acids (aspartate, glutamate, pyruvate and aromatic families) and regulation.

Unit 4 Precursor functions of amino acids

Biosynthesis of creatine and creatinine, polyamines (putresine, spermine, spermidine), catecholamines (dopamine, epinephrine, norepinephrine) and neurotransmitters (serotonin). Porphyrin biosynthesis, catabolism and disorders of porphyrin metabolism.

Unit 5 Biosynthesis of purine and pyrimidine nucleotides

De novo synthesis of purine (adenine, guanine) and pyrimidine (cytosine, uracil, thymine) nucleotides, regulation and salvage pathways.

Unit 6 Deoxyribonucleotides and synthesis of nucleotide triphosphate

Biosynthesis of deoxyribonucleotides and its regulation, conversion to triphosphates, biosynthesis of coenzyme nucleotides.

Unit 7 Degradation of purine and pyrimidine nucleotides

Digestion of nucleic acids, degradation of purine and pyrimidine nucleotides. Inhibitors of nucleotide metabolism. Disorders of purine and pyrimidine metabolism – Lesch-Nyhan syndrome, Gout, SCID, adenosine deaminase deficiency.

Unit 8 Integration of metabolism

Integration of metabolic pathways (carbohydrate, lipid and amino acid metabolic pathways), tissue specific metabolism (brain, muscle, and liver).

C-7 : METABOLISM OF AMINO ACIDS AND NUCLEOTIDES (PRACTICAL) SEMESTER – III

Marks:50

CREDITS: 2

1. Assay of serum transaminases – SGOT and SGPT.
2. Estimation of serum urea.
3. Estimation of serum uric acid.
4. Estimation of serum creatinine.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4 / BRV ISBN: 978-0-470-60152-5.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE) C-8 : HUMAN PHYSIOLOGY (THEORY) SEMESTER - IV

Marks:50

CREDITS: 4

Unit 1 Homeostasis and the organization of body fluid compartments

Intracellular, extracellular and interstitial fluid. Homeostasis, control system and their components. Plasma as an extracellular fluid, RBC, molecular mechanism of blood coagulation, role of vitamin K in coagulation, anticoagulant and fibrinolytic systems. Anemias, polycythemia, haemophilia and thrombosis.

Unit 2 Cardiovascular physiology

Pressure, flow and resistance. Anatomy of heart. Physiology of the cardiac muscle, automaticity of the cardiac muscle contraction, excitation contraction coupling, relationship between cardiac cycle, heart sound, ventricular volumes and the ECG, control of cardiac function and output. The arterial system, venous system, the microcirculation and mechanics of capillary fluid exchange. Control of blood flow to the tissues. Portal circulations. Hypertension, congestive heart disease, atherosclerosis and myocardial infarction.

Unit 3 Respiration

Organization of the pulmonary system. Mechanism of respiration, pulmonary ventilation and related volumes, pulmonary circulation. Principles of gas exchange and transport. Regulation of respiration. Pulmonary oedema and regulation of pleural fluid. Hypoxia, hypercapnea, pulmonary distress, emphysema, ARDS.

Unit 4 Renal physiology

Anatomy of the kidney and the nephron. Regulation of renal blood flow. Cell biology of the Bowmans' capsule. Physiology of glomerular filtration and GFR. Tubular processing of the glomerular filtrate. Micturition reflex and voluntary control of micturition. Regulation of ECF electrolyte and water content, blood volume and long term blood pressure. Blood buffer systems, renal and pulmonary control of blood pH, renal clearance. Assessment of kidney function. Acidosis and alkalosis. Glomerular nephritis, renal failure, dialysis and diuretics.

Unit 5 Gastrointestinal and hepatic physiology

Histology of the gastrointestinal tract. Propulsion and motility of food and digested material. Enteric reflexes, secretory functions of the gastrointestinal tract, digestion and absorption of macro and micronutrients. Peptic ulcer, regurgitation, diarrhea and constipation. Anatomy of the hepatic lobule and blood flow into the liver. Formation and secretion of bile. enterohepatic cycle, reticuloendothelial system, metabolic importance of liver. Liver function tests. Jaundice, liver cirrhosis and fatty liver.

Unit 6 Musculoskeletal system

Bone structure and formation. Physiology of muscle contraction in striated and non-striated muscle.

Unit 7 Reproductive physiology

Sex determination and differentiation. Development of female and male genital tracts. Spermatogenesis, capacitation and transport of sperm, blood testis barrier. Ovarian function and its control. Uterine changes, fertilization and implantation. Placenta as a feto- maternal unit, gestation and parturition.

Unit 8 Neurochemistry and neurophysiology

Central Nervous system. Peripheral Nervous system. Blood brain barrier. Membrane potentials. Synaptic transmission. Neurotransmitters. Sensory receptors and neural pathways. Somatic sensation, EEG, sleep, coma, learning and memory.

SEMESTER - IV

Marks:50

CREDITS: 2

C-8 : HUMAN PHYSIOLOGY (PRACTICALS)

1. Hematology.
 - a. RBC and WBC counting
 - b. Differential leucocyte count.
 - c. Clotting time.
2. Estimation of haemoglobin.
3. Separation of plasma proteins.
4. Determination of total iron binding capacity.
5. Pulmonary function tests, spirometry and measurement of blood pressure.
6. Histology of connective tissue, liver and brain (permanent slides).
7. Case studies (Renal clearance, GFR, ECG).

SUGGESTED READINGS

1. Vander's Human Physiology (2008) 11th ed., Widmaier, E.P., Raff, H. and Strang, K.T., McGraw Hill International Publications (New York), ISBN: 978-0-07-128366-3.
2. Harper's Biochemistry (2012) 29th ed., Murray, R.K., Granner, D.K., Mayes and P.A., Rodwell, V.W., Lange Medical Books/McGraw Hill. ISBN:978-0-07-176-576-3.
3. Textbook of Medical Physiology (2011) 10th ed., Guyton, A.C. and Hall, J.E., Reed Elseviers India Pvt. Ltd. (New Delhi). ISBN: 978-1-4160-4574-8.
4. Fundamental of Anatomy and Physiology (2009), 8th ed., Martini, F.H. and Nath, J.L., Pearson Publications (San Francisco), ISBN: 10:0-321-53910-9 / ISBN: 13: 978-0321-53910-6.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE) C-9 : GENE ORGANIZATION, REPLICATION AND REPAIR (THEORY) SEMESTER - IV

Marks:50

CREDITS: 4

Unit 1 Structure of DNA

DNA structure, features of the double helix, various forms of DNA, denaturation and reassociation of DNA.

Unit 2 Genes and genomic organization

Genome sequence and chromosome diversity, definition of a gene, organization of genes in viruses, bacteria, animals and plants. Nucleosome structure and packaging of DNA into higher order structures.

Unit 3 Replication of DNA

The chemistry of DNA synthesis, DNA polymerase, the replication fork, origin of replication, enzymes and proteins in DNA replication, various modes of replication, stages of replication of *E. coli* chromosome, relationship between replication and cell division, replication in eukaryotes. Comparison of replication in prokaryotes and eukaryotes. Inhibitors of DNA replication and applications in medicine. Supercoiling of DNA and its importance, topoisomerases, critical role of topoisomerases in cell, topoisomerase inhibitors and their application in medicine.

Unit 4 Recombination and transposition of DNA

Homologous recombination, proteins and enzymes in recombination, site-specific recombination, biological roles of site-specific recombination, transposition, three classes of transposable elements, importance of transposable elements in horizontal transfer of genes and evolution.

Unit 5 Molecular basis of mutations

Importance of mutations in evolution of species. Types of mutations - transition, transversions, frame shift mutations, mutations induced by chemicals, radiation, transposable elements, Ames test.

Unit 6 Various modes of DNA repair

Replication errors and mismatch repair system, repair of DNA damage, direct repair, base excision repair, nucleotide excision repair, recombination repair, translesion DNA synthesis, DNA repair deficiency disorder.

C-9 : GENE ORGANIZATION, REPLICATION AND REPAIR (PRACTICALS) SEMESTER – IV

Marks:50

CREDITS: 2

1. Ultraviolet absorption spectrum of DNA and RNA.
2. Determination of DNA and RNA by spectrophotometric method.
3. To study the viscosity of DNA solutions.
4. Isolation of chromosomal DNA from *E. coli* cells.

SUGGESTED READINGS

1. Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold spring Harbor (New York), ISBN:0-321-50781 / ISBN:978-0-321-50781-5.
2. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W. H. Freeman & Company (New York), ISBN:13: 978-1-4292-3414-6 / ISBN:10-14641-0962-1.
3. Principles of Genetics (2010) 5th ed., Snustad, D.P. and Simmons, M.J., John Wiley & Sons Asia, ISBN:978-0-470-39842-5.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE) C-10 : HORMONE : BIOCHEMISTRY AND FUNCTION (THEORY) SEMESTER – IV

Marks:50

CREDITS: 4

Unit 1 Introduction to endocrinology

Functions of hormones and their regulation. Chemical signaling - endocrine, paracrine, autocrine, intracrine and neuroendocrine mechanisms. Chemical classification of hormones, transport of hormones in the circulation and their half-lives. Hormone therapy. General introduction to Endocrine methodology.

Unit 2 Hormone mediated signaling

Hormone receptors - extracellular and intracellular. Receptor - hormone binding, Scatchard analysis. G protein coupled receptors, G proteins, second messengers - cAMP, cGMP, Ca₂₊, NO. Effector systems - adenylyl cyclase, guanylyl cyclase, PDE, PLC. Protein kinases (PKA, PKB, PKC, PKG). Receptor tyrosine kinases - EGF, insulin, MAP kinase cascade, JAK - STAT pathway. Steroid hormone/ thyroid hormone receptor mediated gene regulation. Receptor regulation and cross talk.

Unit 3 Hypothalamic and pituitary hormones

Hypothalamic - pituitary axis. Study the physiological and biochemical actions of hypothalamic hormones, pituitary hormones - GH, prolactin, TSH, LH, FSH, POMC peptide family, oxytocin and vasopressin, feedback regulation cycle. Endocrine disorders - gigantism, acromegaly, dwarfs, pigmies and diabetes insipidus.

Unit 4 Thyroid hormone

Thyroid gland. Biosynthesis of thyroid hormone and its regulation; its physiological and biochemical action. Pathophysiology - Goiter, Graves disease, cretinism, myxedema, Hashimoto's disease.

Unit 5 Hormones regulating Ca₂₊ homeostasis

PTH, Vitamin D and calcitonin. Mechanism of Ca₂₊ regulation and pathways involving bone, skin, liver, gut and kidneys. Pathophysiology - rickets, osteomalacia, osteoporosis.

Unit 6 Pancreatic and GI tract hormones

Regulation of release of insulin, glucagon, gastrin, secretin, adipolectin and leptin. Summary of hormone metabolite control of GI function. Physiological and biochemical action. Pathophysiology - diabetes type I and type II.

Unit 7 Hormones of adrenals

Aldosterone, renin angiotensin system, cortisol, epinephrine and norepinephrine. Fight or flight response, stress response. Pathophysiology – Addison's disease, Conn's syndrome, Cushing syndrome.

Unit 8 Reproductive hormones

Male and female sex hormones. Interplay of hormones during reproductive cycle, pregnancy, parturition and lactation. Hormone based contraception.

C-10 : HORMONE : BIOCHEMISTRY AND FUNCTION (PRACTICALS) SEMESTER – IV

Marks:50

CREDITS: 2

1. Glucose tolerance test.
2. Estimation of serum Ca^{2+} .
3. Estimation of serum T4.
4. HCG based pregnancy test.
5. Estimation of serum electrolytes.
6. Case studies.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M. W.H. Freeman & Company (New York), ISBN:13: 978-1-4641-0962-1 / ISBN:10-14641-0962-1.
2. Vander's Human Physiology (2008) 11th ed., Widmaier, E.P., Raff, H. and Strang, K.T. McGraw Hill International Publications, ISBN: 978-0-07-128366-3.
3. Endocrinology (2007) 6th ed., Hadley, M.C. and Levine, J.E. Pearson Education (New Delhi), Inc. ISBN: 978-81-317-2610-5.
4. The Cell: A Molecular Approach (2009) 5th Ed. Cooper, G.M. and Hausman, R.E. ASM Press & Sunderland, (Washington DC), Sinauer Associates. (MA). ISBN:978-0-87893-300-6.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE) SEC-1 : TOOLS AND TECHNIQUES IN BIOCHEMISTRY SEMESTER – III

Marks: 50

CREDITS : 2

Unit 1 Biochemical reagents and solutions

Safety practices in the laboratory. Preparation and storage of solutions. Concepts of solution concentration and storing solutions. Quantitative transfer of liquids. Concept of a buffer, Henderson-Hasselbach equation, working of a pH meter.

Exercise

Preparation of a buffer of given pH and molarity.

Unit 2 Spectrophotometric techniques

Principle and instrumentation of UV-visible and fluorescence spectroscopy.

Exercises

Determination of the absorption maxima and molar extinction coefficient (of a relevant organic molecule).

Measurement of fluorescence spectrum.

Determination of concentration of a protein solution by Lowry/BCA method.

Unit 3 Introduction and importance of virtual labs in biochemistry

SUGGESTED READINGS

1. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN:978-0-470-85602-4 / ISBN:978-0-470-85603-1.
2. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder, D., W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.
3. An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN:13: 978-0-07-099487-4 / ISBN:10: 0-07-099487-0.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)

SEC-2 : PROTEIN PURIFICATION TECHNIQUES

SEMESTER – III

Marks: 50

CREDITS: 2

Unit 1 Purification and characterization of a protein from a complex mixture (native or heterologously expressed) involving the following methods/techniques Exercises

Preparation of the sample.
Ion-exchange chromatography.
Gel filtration chromatography.
Affinity chromatography.
Electrophoresis.

Unit 2 Demonstration of High Performance Liquid Chromatography (HPLC)

SUGGESTED READINGS

1. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN:978-0-470-85602-4 / ISBN:978-0-470-85603-1.
2. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder, D., W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.
3. An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN:13: 978-0-07-099487-4 / ISBN:10: 0-07-099487-0.

B.Sc. (HONS) BIOCHEMISTRY (CBCS STRUCTURE)

SEC-3 : CLINICAL BIOCHEMISTRY SEMESTER – III

Marks: 50

CREDITS: 2

Unit 1 Introduction

Organization of clinical laboratory, Introduction to instrumentation and automation in clinical biochemistry laboratories safety regulations and first aid. General comments on specimen collection, types of specimen for biochemical analysis. Precision, accuracy, quality control, precautions and limitations.

Exercises

Collection of blood and storage.
Separation and storage of serum.

Unit 2 Evaluation of biochemical changes in diseases

Basic hepatic, renal and cardiovascular physiology. Biochemical symptoms associated with disease and their evaluation. Diagnostic biochemical profile.

Unit 3 Assessment of glucose metabolism in blood

Clinical significance of variations in blood glucose. Diabetes mellitus.

Exercises

Estimation of blood glucose by glucose oxidase peroxidase method.

Unit 4 Lipid profile

Composition and functions of lipoproteins. Clinical significance of elevated lipoprotein.

Exercises

Estimation of triglycerides.

Unit 5 Liver function tests

Exercises

Estimation of bilirubin (direct and indirect).

Unit 6 Renal function tests and urine analysis

Use of urine strip / dipstick method for urine analysis.

Exercises

Quantitative determination of serum creatinine and urea.

Unit 7 Tests for cardiovascular diseases

Involvement of enzymes in diagnostics of heart disease including aspartate transaminase, isoenzymes of creatine kinase and lactate dehydrogenase and troponin.

Exercises

Estimation of creatine kinase MB.

SUGGESTED READINGS

1. Medical Laboratory Technology - a Procedure Manual for Routine Diagnostic Tests Vol. I (2010), Mukherjee, K.L., Tata Mc Graw–Hill Publishing Company Limited (New Delhi). ISBN:9780070076594 / ISBN:9780070076631
2. Medical Laboratory Technology - a Procedure Manual for Routine Diagnostic Tests Vol. II (2010), Mukherjee, K.L., Tata Mc Graw – Hill Publishing Company Ltd. (New Delhi), ISBN: 9780070076648.
3. Medical Biochemistry (2005) 2nd ed., Baynes, J.W. and Dominiczak, M.H., Elsevier Mosby Ltd. (Philadelphia), ISBN:0-7234-3341-0.
4. Experimental Biochemistry: A Student Companion (2005) Rao, B.S. and Deshpande, V., IK International Pvt. Ltd. (New Delhi), ISBN:81-88237-41-8.

B.Sc. (HONS) BIOCHEMISTRY (CBCS STRUCTURE)

SEC-4 : BIOINFORMATICS SEMESTER - IV

Marks : 50

CREDITS: 4

Unit 1 Introduction to bioinformatics

Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - genomics, proteomics, computer aided drug design (structure based and ligand based approaches) and Systems Biology. Applications of bioinformatics.

Unit 2 Biological databases and data retrieval

Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol), file formats.

Exercises

Sequence retrieval (protein and gene) from NCBI.

Structure download (protein and DNA) from PDB.

Molecular file formats - FASTA, GenBank, Genpept, GCG, CLUSTAL, Swiss-Prot, FIR.

Molecular viewer by visualization software.

Unit 3 Sequence alignment

Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms, amino acid substitution matrices (PAM and BLOSUM), BLAST and CLUSTALW.

Exercises

BLAST suite of tools for pairwise alignment.

Multiple sequence alignment using CLUSTALW.

Unit 4 Phylogenetic analysis

Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.

Exercise

Generating phylogenetic tree using MEGA software.

Unit 5 Protein structure prediction and analysis

Levels of protein structure. Protein tertiary structure prediction methods - homology modeling, fold recognition and *ab-initio* methods. Significance of Ramachandran map.

Exercises

Primary sequence analyses (Protparam).

Secondary structure prediction (GOR, nnPredict).

Tertiary structure prediction (SWISSMODEL).

Protein structure evaluation - Ramachandran map (PROCHECK).

Unit 6 Genomics

Introduction to genomics, comparative and functional genomics, gene structure in prokaryotes and eukaryotes, gene prediction methods and tools.

Exercise

Gene prediction using GENSCAN and GLIMMER.

SUGGESTED READINGS

1. Bioinformatics: Sequence and Genome Analysis (2001), 1st ed., Mount, D.W. Cold Spring Harbor Laborator Press (New York), ISBN: 0-87969-608-7.
2. Bioinformatics and Functional Genomics (2003), 1st ed., Pevsner, J., John Wiley & Sons, Inc. (New Jersey), ISBN: 0-47121004-8.
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (2005), 3rd ed., Baxevanis, A.D. and Ouellette, B.F., John Wiley & Sons, Inc. (New Jersey), ISBN: 0-47147878-4.
4. Bioinformatics – Principles and Applications (2008), 1st ed. Ghosh, Z. and Mallick, B., Oxford University Press (India), ISBN: 9780195692303.

B.Sc. (HONS) BIOCHEMISTRY (CBCS STRUCTURE)

SEC-5 : RECOMBINANT DNA TECHNOLOGY

SEMESTER - IV

TOTAL MARKS : 50 CREDITS: 2

Unit 1 Work flow for in silicon cloning

Unit 2 Preparation of media, antibiotic solution, culturing of E. coli, isolation of single colonies .

Exercises Preparation of LB broth and agar. Inoculation of medium. Preparation of glycerol stocks of bacterial strains. Obtaining isolated colonies by streak plate method. Preparation of stock solutions.

Unit 3 Overview of plasmid vectors and methods of isolation No. of Hours : 8
Exercises Isolation of plasmid by alkaline lysis method. Isolation of plasmid DNA using column chromatography (kit).

Unit 4 Characterization of plasmid by gel electrophoresis Exercise Digestion of plasmid DNA with restriction enzymes and analysis of the fragments. Unit 5 Cloning of a gene in a vector and functional analysis Polymerases chain reaction (parametric optimization, primer designing), ligation, introduction of DNA construct into host cells, selection of recombinants. Exercises Amplification of DNA segment/gene of interest by PCR. Purification of PCR product, digestion of insert and vector by restriction enzymes for directional cloning, purification of insert and digested vector by gel extraction. Ligation of vector and insert. Preparation of competent cells of E. coli DH5 α and transformation with the ligation mixture. Functional selection of recombinants (blue/white selection and eGFP fluorescence).

SUGGESTED READINGS 1. Molecular Cloning: A laboratory Manual (2012) Vol. 1-3, 4th ed., Green M.R. and Sambrook J., Cold Spring Harbour Laboratory Press (New York). ISBN: 978-1-93611341-5 / ISBN: 978-1-936113-42-2.

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE) C-11 :
CONCEPTS IN GENETICS (THEORY) SEMESTER - V**

TOTAL HOURS : 60

CREDITS: 4

Unit 1 Introduction to model organisms and Mendelism **No. of Hours : 4**

Model organisms: *Escherichia coli*, *Saccharomyces cerevisiae*, *Drosophila melanogaster*, *Caenorhabditis elegans*, *Danio rerio* and *Arabidopsis thaliana*, Basic principles of heredity.

Unit 2 Applications of Mendel's principles & chromosomal basis of heredity

No. of Hours : 6

Laws of probability & binomial expansion, formulating and testing genetic hypothesis, chromosomal basis of Mendelism -Sutton and Boveri hypothesis with experimental evidences.

Unit 3 Extensions of Mendelism

No. of Hours : 4

Allelic variation and gene function - dominance relationships, multiple alleles, lethal alleles and null alleles. Pleiotropy gene interaction - epistatic and non epistatic, interaction between gene(s) and environment. Penetrance and expressivity, norm of reaction and phenocopy.

Unit 4 Genetic definition of a gene

No. of Hours : 4

Complementation test, limitations of *cis-trans* test, intragenic complementation, rII locus of phage T₄ and concept of cistron

Unit 5 Genetics of bacteria and viruses

No. of Hours : 6

Mechanism of genetic exchange - conjugation, transformation and transduction. Gene mapping in bacteria.

Unit 6 Linkage, crossing over and mapping techniques

No. of Hours : 6

Linkage and crossing over, genetic mapping in eukaryotes, centromere mapping with ordered tetrads, cytogenetic mapping with deletions and duplications in *Drosophila*, detection of linked loci by pedigree analysis in humans and somatic cell hybridization for positioning genes on chromosomes.

Unit 7 Human pedigree analysis

No. of Hours : 6

Pedigree conventions, characteristics of dominant and recessive inheritance. Applications of pedigree analysis.

Unit 8 The genetic control of development and sex determination

No. of Hours : 6

Model organism for genetic analysis, *Drosophila* development, maternal effect genes, morphogens and zygotic gene activity in development, sex chromosomes and sex determination, dosage compensation of X-linked genes.

Unit 9 Organelle heredity and epigenetics

No. of Hours : 4

Extra nuclear inheritance, tests for organelle heredity and maternal effect, epigenetic mechanisms of transcriptional regulation & genomic imprinting.

Unit 10 Chromosomal aberrations**No. of Hours : 4**

Variations in chromosome number- monosomy and trisomy of sex and autosomes.
Variations in chromosome structure - inversions, deletions, duplications and translocations.

Unit 11 Inheritance of complex traits & population genetics**No. of Hours : 6**

Inheritance of complex trait, analysis of quantitative traits, narrow and broad sense heritability, quantitative trait loci (QTL) and their identification. Hardy- Weinberg law, predicting allele and genotype frequencies and exceptions to Hardy-Weinberg principle.

Evolutionary genetics**No. of Hours : 4**

Molecular evolution - analysis of nucleotide and amino acid sequences, molecular phylogenies, homologous sequences, phenotypic evolution and speciation.

**C-11 : CONCEPTS IN GENETICS (PRACTICALS)
SEMESTER - V****TOTAL HOURS : 60****CREDITS: 2**

1. Squash preparation of salivary glands of Dipteran larva to observe polytene chromosomes.
2. Induction of polyploidy in onion roots.
3. Smear technique to demonstrate sex chromatin in buccal epithelial cells.
4. Monohybrid crosses in *Drosophila* for studying autosomal and sex linked inheritance.
5. PTC testing in a population and calculation of allele and genotype frequencies.
6. Study of abnormal human karyotype and pedigrees (dry lab)
7. Conjugation in bacteria

SUGGESTED READINGS

1. Genetics (2012) 6th ed., Snustad, D.P. and Simmons, M.J., John Wiley & Sons. (Singapore), ISBN: 978-1-118-09242-2.
2. Genetics - A Conceptual Approach (2012), 4th ed., Pierce, B.A., W.H. Freeman & Co. (New York), ISBN:13:978-1-4292-7606-1 / ISBN:10:1-4292-7606-1.
3. An Introduction to Genetic Analysis (2010), 10th ed., Griffiths, A.J.F, Wessler, S. R, Carroll, S. B. and Doebley, J., W.H. Freeman & Company (New York), ISBN:10: 1-4292-2943-8.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
C-12 : GENE EXPRESSION AND REGULATION (THEORY)
SEMESTER - V

TOTAL HOURS : 60

CREDITS: 4

Unit 1 Biosynthesis of RNA in prokaryotes

No. of Hours : 8

RNA polymerases, transcription cycle in bacteria, sigma factor, bacterial promoters, identification of DNA binding sites by DNA footprinting, the three stages of RNA synthesis, initiation, elongation and termination, rho-dependent and rho-independent termination. Inhibitors of transcription and applications as anti-microbial drugs.

Unit 2 Biosynthesis of RNA in eukaryotes

No. of Hours : 8

Comparison between prokaryotic and eukaryotic transcription. Transcription by RNA polymerase II, RNA polymerase II core promoters, general transcription factors, various types of RNA processing, transcription by RNA polymerase I and III. Inhibitors of eukaryotic transcription and their applications. Comparison of fidelity of transcription and replication.

Unit 3 RNA splicing

No. of Hours : 6

Chemistry of RNA splicing, the spliceosome machinery, splicing pathways, group I and group II introns, alternative splicing, exon shuffling, RNA editing.

Unit 4 The genetic code

No. of Hours : 4

Degeneracy of the genetic code, wobble in the anticodon, features of the genetic code, nearly universal code.

Unit 5 Biosynthesis of proteins

No. of Hours : 10

Messenger RNA, transfer RNA, attachment of amino acids to tRNA, the ribosome - initiation, elongation and termination of translation, regulation of translation. Comparison of prokaryotic and eukaryotic protein synthesis. Use of antibiotics in understanding protein synthesis and applications in medicine.

Unit 6 Protein targeting and degradation

No. of Hours : 6

Post translational modifications, glycosylation, signal sequences for nuclear transport, bacterial signal sequences, import of proteins by receptor mediated endocytosis, specialized systems for protein degradation.

Unit 7 Regulation of gene expression in prokaryotes

No. of Hours : 8

Principles of gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, DNA binding domains, regulation of lac operon and trp operon, induction of SOS response, synthesis of ribosomal proteins, regulation by genetic recombination, transcriptional regulation in λ bacteriophage.

Unit 8 Regulation of gene expression in eukaryotes

No. of Hours : 10

Heterochromatin, euchromatin, chromatin remodeling, regulation of galactose metabolism in yeast, regulation by phosphorylation of nuclear transcription factors, regulatory RNAs, riboswitches, RNA interference, synthesis and function of miRNA molecules, phosphorylation of nuclear transcription factors.

C-12 : GENE EXPRESSION AND REGULATION (PRACTICALS)
SEMESTER - V

TOTAL HOURS : 60

CREDITS: 2

1. Extraction of total nucleic acids ^(DNA & RNA) from plant tissue. ~~(transformation)~~
2. Diauxic growth curve effect.
3. Isolation of mRNA from yeast by affinity chromatography. ~~(ribosome)~~
4. Effect of inhibitors on protein synthesis. ~~(bacteria)~~
5. Accumulation of protein due to proteasome inhibitors.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman & Company (New York), ISBN:13: 978-1-4292-3414-6 / ISBN:10-14641-0962-1.
2. Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York), ISBN:0-321-50781 / ISBN: 978-0-321-50781-5.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
C-13 : GENETIC ENGINEERING AND BIOTECHNOLOGY
(THEORY)
SEMESTER - VI

TOTAL HOURS : 60

CREDITS: 4

Unit 1 Introduction to recombinant DNA technology

No. of Hours : 6

Overview of recombinant DNA technology. Restriction and modification systems, restriction endonucleases and other enzymes used in manipulating DNA molecules, separation of DNA by gel electrophoresis. Extraction and purification of plasmid and bacteriophage DNA.

Unit 2 Cloning vectors for prokaryotes and eukaryotes

No. of Hours : 10

Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors based on *E. coli* plasmids, pBR322, pUC8, pGEM3Z. Cloning vectors based on M13 and λ bacteriophage. Vectors for yeast, higher plants and animals.

Unit 3 Joining of DNA fragments

No. of Hours : 4

Ligation of DNA molecules. DNA ligase, sticky ends, blunt ends, linkers and adapters. Synthetic oligonucleotides, synthesis and use.

Unit 4 Introduction of DNA into cells and selection for recombinants

No. of Hours : 6

Uptake of DNA by cells, preparation of competent cells. Selection for transformed cells. Identification for recombinants - insertional inactivation, blue-white selection. Introduction of phage DNA into bacterial cells. Identification of recombinant phages. Introduction of DNA into animal cells, electroporation.

Unit 5 Methods for clone identification

No. of Hours : 6

The problem of selection, direct selection, marker rescue. Gene libraries, identification of a clone from gene library, colony and plaque hybridization probing, methods based on detection of the translation product of the cloned gene.

Unit 6 Polymerase chain reaction

No. of Hours : 4

Fundamentals of polymerase chain reaction, designing primers for PCR. Studying PCR products. Cloning PCR products. Real time PCR.

Unit 7 DNA sequencing

No. of Hours : 6

DNA sequencing by Sanger's method, modifications based on Sanger's method. Automated DNA sequencing. Pyrosequencing.

Unit 8 Expression of cloned genes

No. of Hours : 6

Vectors for expression of foreign genes in *E. coli*, cassettes and gene fusions. Challenges in producing recombinant protein in *E. coli*. Production of recombinant protein by eukaryotic cells. Fusion tags and their role in purification of recombinant proteins.

Unit 9 Applications of genetic engineering in Biotechnology

No. of Hours : 12

Site-directed mutagenesis and protein engineering. Applications in medicine, production of recombinant pharmaceuticals such as insulin, human growth hormone, factor VIII.

Recombinant vaccines. Gene therapy. Applications in agriculture - plant genetic engineering, herbicide resistant crops, problems with genetically modified plants, safety concerns.

**C-13 : GENETIC ENGINEERING AND BIOTECHNOLOGY (PRACTICALS)
SEMESTER - VI**

TOTAL HOURS : 60

CREDITS: 2

1. Isolation of plasmid DNA from *E. coli* cells.
2. Digestion of plasmid DNA with restriction enzymes.
3. Amplification of a DNA fragment by PCR. (Protocol)
4. Transformation of *E. coli* cells with plasmid DNA. (Protocol)
5. Hyper-expression of poly histidine-tagged recombinant protein and purification using Ni-affinity-resin.

SUGGESTED READINGS

1. Gene Cloning and DNA Analysis (2010) 6th ed., Brown, T.A., Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
2. Principles of Gene Manipulation and Genomics (2006) 7th ed., Primrose, S.B., and Twyman, R. M., Blackwell publishing (Oxford, UK) ISBN:13: 978-1-4051-3544-3.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) 4th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC), ISBN: 978-1-55581-498-4 (HC).

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
C-14 : IMMUNOLOGY (THEORY)
SEMESTER - VI

TOTAL HOURS : 60

CREDITS: 4

Unit 1 Cells and organs of the immune system

Hematopoiesis, cells of the immune system, primary and secondary lymphoid organs and tissues (MALT).

No. of Hours : 4

Unit 2 Innate immunity and leukocyte extravasation

Anatomical barriers, cell types of innate immunity, soluble molecules and membrane associated receptors (PRR), connections between innate and adaptive immunity, cell adhesion molecules, chemokines, leukocyte extravasation, localized and systemic response.

No. of Hours : 6

Unit 3 Immunogens and antigens

Antigens and haptens, factors that dictate immunogenicity, B and T cell epitopes.

No. of Hours : 4

Unit 4 Antibody structure and function

Structure and distribution of classes and subclasses of immunoglobulins (Ig), Ig fold, effector functions of antibody, antigenic determinants on Ig and Ig super family.

No. of Hours : 4

Unit 5 Generation of receptor diversity

Dreyer-Bennett hypothesis, multigene organization of Ig locus, mechanism of V region DNA rearrangement, ways of antibody diversification.

No. of Hours : 4

Unit 6 Biology of the B lymphocyte

Antigen independent phase of B cell maturation and selection, humoral response – T-dependent and T-independent response, anatomical distribution of B cell populations.

No. of Hours : 6

Unit 7 Complement system

Complement activation by classical, alternate and MB lectin pathway, biological consequences of complement activation, regulation and complement deficiencies.

No. of Hours : 4

Unit 8 MHC complex and antigen presentation

General organization and inheritance of MHC, structure, distribution and role of MHC class I and class II proteins, linkage disequilibrium, pathways of antigen processing and presentation.

No. of Hours : 4

Unit 9 Biology of the T lymphocyte

Structure and role of T cell receptor, and co-receptor, T cell development, generation of receptor diversity, selection and differentiation.

No. of Hours : 4

Unit 10 Cell mediated cytotoxic responses

General properties of effector T cells, cytotoxic T cells (T_c), natural killer cells; NKT cells and antibody dependent cellular cytotoxicity (ADCC).

No. of Hours : 4

Unit 11 Tolerance, autoimmunity and hypersensitivity

Organ specific and systemic autoimmune diseases, possible mechanisms of induction of autoimmunity, Gell and Coombs classification, IgE mediated (Type I) hypersensitivity,

No. of Hours : 8

antibody mediated cytotoxic (Type II) hypersensitivity, immune complex mediated (type III) hypersensitivity and delayed type (Type IV) hypersensitivity.

Unit 12 Transplantation immunology and vaccines

No. of Hours : 8

Immunological basis of graft rejection, clinical manifestations, immunosuppressive therapy and privileged sites. Vaccines - active and passive immunization, types of vaccines.

**C-14 : IMMUNOLOGY (PRACTICALS)
SEMESTER - VI**

TOTAL HOURS : 60

CREDITS: 2

1. Isolation of lymphocytes from blood and macrophages from peritoneal cavity or spleen. (Practical)
2. Purification of immunoglobulins. (Practical)
3. Assays based on precipitation reactions - Ouchterlony double diffusion (ODD) and Mancini radial immunodiffusion. (Practical)
4. Assays based on agglutination reactions - Blood typing (active) & passive agglutination.
5. Enzyme linked immune-sorbent assay (ELISA). (Demonstration)

SUGGESTED READINGS

1. Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A., W.H Freeman and Company (New York), ISBN:13: 978-0-7167-8590-3 / ISBN: 10:0-7617-8590-0.
2. Immunology: A Short Course (2009) 6th ed., Coico, R and Sunshine, G., John Wiley & sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.
3. Janeway's Immunobiology (2012) 8th ed., Murphy, K., Mowat, A., and Weaver, C.T., Garland Science (London & New York), ISBN: 978-0-8153-4243-4.

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVES**

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DSE-1: NUTRITIONAL BIOCHEMISTRY (THEORY)
SEMESTER - V/VI

TOTAL HOURS: 60

CREDITS: 4

Unit 1 Introduction to Nutrition and Energy Metabolism

No. of Hours : 8

Defining Nutrition, role of nutrients. Unit of energy, Biological oxidation of foodstuff. measurement of energy content of food, Physiological energy value of foods, SDA. Measurement of energy expenditure. Direct and Indirect Calorimetry, factors affecting thermogenesis, energy utilization by cells, energy output – Basal and Resting metabolism, physical activity, factors affecting energy input - hunger, appetite, energy balance Energy expenditure in man. Estimating energy requirements, BMR factors Recommended Nutrient Intakes (RNI) and Recommended Dietary Allowances for different age groups.

Unit 2 Dietary carbohydrates and health

No. of Hours : 8

Review functions of carbohydrates. Digestion, absorption, utilization and storage, hormonal regulation of blood glucose. Dietary requirements and source of carbohydrates, Dietary fiber, role of fibre in lipid metabolism, colon function, blood glucose level and GI tract functions.

Unit 3 Dietary lipid and health

No. of Hours : 8

Review of classification, sources, functions, digestion, absorption, utilization and storage. Essential Fatty Acids; Functions of EFA, RDA, – excess and deficiency of EFA. Lipotropic factors, role of saturated fat, cholesterol, lipoprotein and triglycerides. Importance of the following: a) Omega – fatty acids. Omega 3/ omega 6 ratio b) Phospholipids c) Cholesterol in the body d) Mono, Polyunsaturated and Saturated Fatty Acids. Dietary implications of fats and oils, Combination ratios of n6 and n3, MUFA, PUFA and SFA.

Unit 4 Dietary Proteins and health

No. of Hours : 8

Review of functions of proteins in the body, Digestion and absorption. Essential and Non-essential amino acids. Amino Acid Availability Antagonism, Toxicity and Imbalance, Amino acid Supplementation. Effects of deficiency. Food source and Recommended Dietary Allowances for different age group. Amino acid pool. NPU, Biological Value, Nitrogen balance. PEM and Kwashiorkor.

Unit 5 Fat and water soluble Vitamins

No. of Hours : 8

Vitamin A, C, E, K and D Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME), Deficiency. Role of Vitamin A as an antioxidant, in Visual cycle, dermatology and immunity. Role of Vitamin K in Gamma carboxylation. Role of Vitamin E as an antioxidant. Extra-skeletal role of Vitamin D and its effect on bone physiology. Hypervitaminosis. Vitamin C role as cofactor in amino acid modifications. Niacin- Metabolic interrelation between tryptophan, Niacin and NAD/ NADP. Vitamin B6-Dietary source, RDA, conversion to Pyridoxal Phosphate. Role in metabolism, Biochemical basis for deficiency symptoms. Vitamin B12 and folate; Dietary source, RDA, absorption, metabolic role Biochemical basis for deficiency symptoms.

Unit 6 Minerals

No. of Hours : 12

Calcium, Phosphorus and Iron - Distribution in the body digestion, Absorption, Utilization, Transport, Excretion, Balance, Deficiency, Toxicity, Sources, RDA. Calcium: Phosphorus ratio, Role of iron in prevention of anemia. Iodine and iodine cycle. Iodine, Fluoride, Mg, Cu,

Zn, Se, Manganese, Chromium, Molybdenum Distribution in the human body, Physiology, Function, deficiency, Toxicity and Sources

Unit 7 Assessment of Nutritional status

No. of Hours : 4

Anthropometric measurements; Z scores, BMI, skinfold, circumference ratios. Biochemical assessment; Basal metabolic panel, Comprehensive metabolic panel, CBC, Urine Analysis, Assessment of Anemia, ROS assessment, GTT and glycosylated Hb, Differential diagnosis of B12 and folate.

Unit 8 Food and drug interactions and Nutriceuticals

No. of Hours : 4

Nutrient interactions affecting ADME of drugs, Alcohol and nutrient deficiency, Anti-depressants, psychoactive drugs and nutrient interactions, Appetite changes with drug intakes and malnutrition. Food as medicine.

**DSE-1: NUTRITIONAL BIOCHEMISTRY (PRACTICALS)
SEMESTER - V/VII**

TOTAL HOURS : 60

CREDITS: 2

1. Bioassay for vitamin B12/B1/ *folate and*
2. Homocystiene estimation.
3. Serum/ urine MMA estimation.
4. Anthropometric identifications for Kwashiorkor, Marasmus and Obesity *(Demonstration)*
5. Determination of oxidative stress: TBARS, antioxidant enzymes in hemolysate.
6. Vitamin A/E estimation in serum.
7. ~~Bone densitometry~~ bone-ultrasound test demonstration (visit to a nearby clinic)

SUGGESTED READINGS

1. Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
2. Nutrition for health, fitness and sport (2013) ; Williams.M.H,Anderson,D.E, Rawson,E.S. McGraw Hill international edition. ISBN-978-0-07-131816-7.
3. Krause's Food and Nutrition Care process.(2012); Mahan, L.K Strings,S.E, Raymond,J. Elsevier's Publications. ISBN- 978-1-4377-2233-8.
4. The vitamins, Fundamental aspects in Nutrition and Health (2008); G.F. Coombs Jr. Elsevier's Publications. ISBN-13- 978-0-12- 183493-7.
5. Principles of Nutritional Assessment (2005) Rosalind Gibson. Oxford University Press.

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DSE-2: BASIC MICROBIOLOGY (THEORY)
SEMESTER – V/VI**

Total Hours : 60

CREDITS: 4

Unit 1 History of Development of Microbiology

No. of Hours: 12

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming. Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

Unit 2 Diversity of Microbial world

No. of Hours: 8

Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms. General characteristics of different groups: acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.

Unit 3 Viruses, viroids and prions

No. of Hours: 10

An introduction to viruses with special reference to the structure and replication of the following: Poxvirus, Poliovirus, HIV, T4 and λ phage, lytic and lysogenic cycles.

Unit 4 Bacteria

No. of Hours: 10

An account of typical eubacteria, chlamydiae & rickettsiae (obligate intracellular parasites), mycoplasma, and archaeobacteria (extremophiles). Applications of bacteria in industry, environment and food.

Unit 5 Algae

No. of Hours: 6

History of phycology; General characteristics of algae including occurrence, thallus organization, algae cell ultra structure, pigments, flagella, eyespot food reserves and vegetative, asexual and sexual reproduction. Applications of Algae in agriculture, industry, environment and food.

Unit 6 Fungi

No. of Hours: 6

Historical developments in the field of Mycology, significant contributions of eminent mycologists. General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra- structure, thallus organization and aggregation, fungal wall structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism. Economic Importance of Fungi in Agriculture, environment, Industry, medicine, food, biodeterioration, mycotoxins

Unit 7 Protozoa

No. of Hours: 4

General characteristics with special reference to Amoeba

Unit 3 Scope of Microbiology

No. of Hours: 4

DSE-2 : BASIC MICROBIOLOGY (PRACTICALS)
SEMESTER - V/VI

Total Hours : 60

CREDITS: 2

1. Microbiology Laboratory Practices and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter)
3. Preparation and sterilization of culture media for bacterial cultivation
4. Study of different shapes of bacteria, fungi, algae, protozoa using permanent slides/pictographs
5. Staining of bacteria using Gram stain
6. Isolation of pure cultures of bacteria by streaking method.
7. Estimation of CFU count.

SUGGESTED READINGS

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. W M.T.Brown Publishers.
2. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DSE-3 : MOLECULAR BASIS OF NON-INFECTIOUS HUMAN
DISEASES (THEORY)
SEMESTER – V/VI

Total Hours : 60

CREDITS: 4

Unit 1 Nutritional disorders

No. of Hours : 10

Overview of major and minor nutrient components in the diet. Balanced diet and the concept of RDA. Nutrient deficiencies; Kwashiorkor and Marasmus, Scurvy, beri beri, pellagra and B12 deficiency, Xerophthalmia and Night blindness, Vitamin D deficiency, Vitamin K deficiency. Discuss with relation to biochemical basis for symptoms.

Unit 2 Metabolic and Lifestyle disorders

No. of Hours : 12

Obesity and eating disorders like Anorexia nervosa and Bulimia. Diabetes mellitus A metabolic syndrome and the relationship with hypertension, obesity, hypothyroidism and stress. Cardio vascular disorders and Atherosclerosis-defining the broad spectrum of ailments that fall in this category, understanding the factors that contribute to the syndrome, stages of disorder and the management of the condition. Irritable bowel syndrome- biochemistry behind the disorder and the influence of diet, stress and environment on the condition.

Unit 3 Multifactorial complex disorders and Cancer

No. of Hours : 20

Understanding the definition of multifactorial diseases. Polygenic diseases and the relationship of environmental factors and genetic makeup in the onset of diseases.

Cancer: characteristics of a transformed cell, causes and stages of Cancer, molecular basis for neoplastic growth and metastasis, Proto-oncogenes and tumor suppressor genes; Cancer causing mutations; Tumor viruses; Biochemical analysis of cancer; Molecular approaches to cancer treatment.

Disorders of mood : Schizophrenia, dementia and anxiety disorders.

Polycystic ovarian syndrome, Parkinson's disease, ALS.

Unit 4 Diseases due to misfolded proteins

No. of Hours : 8

Introduction to protein folding and proteasome removal of misfolded proteins; etiology and molecular basis for Alzheimer's, Prion diseases, Huntington's Chorea, sickle cell anemia, Thalassemia.

Unit 5 Monogenic diseases

No. of Hours : 10

In born errors in metabolism: PKU, Alkaptonuria, Maple syrup urine disease; Receptor and transport defects: Cystic fibrosis, Long QT syndrome, familial hypercholesterolemia, Achondroplasia. Hemoglobinopathies and clotting disorders.

**DSE-3 : MOLECULAR BASIS OF NON-INFECTIOUS HUMAN DISEASES
(PRACTICALS)
SEMESTER - HV/VI**

Total Hours : 60

CREDITS: 2

1. Anthropometric measurements for normal and high risk individuals and identifications for Kwashiorkor, Marasmus and Obesity (Project)
2. Estimation of homocysteine levels in serum
3. Estimation of glycosylated hemoglobin
4. Permanent slides for different types of cancer
5. Diagnostic profile for assessment of CVS and Diabetes mellitus using case studies.
6. Bone densitometry test demonstration (visit to a nearby clinic)

SUGGESTED READINGS

1. Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
2. Introduction to Human Physiology (2013) 8th edition; Lauralee Sherwood, Brooks/Cole, Cengage Learning.
3. The World of the cell, 7th edition (2009)
4. Genetics (2012) Snustad and Simmons,
5. Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DSE-4 : MOLECULAR BASIS OF INFECTIOUS DISEASES (THEORY)
SEMESTER – V/VI

Total Hours: 60

CREDITS: 4

Unit 1 Classification of infectious agents

No. of Hours : 12

Bacteria, Viruses, protozoa and fungi. Past and present emerging and re-emerging infectious diseases and pathogens. Source, reservoir and transmission of pathogens, Antigenic shift and antigenic drift. Host parasite relationship, types of infections associated with parasitic organisms. Overview of viral and bacterial pathogenesis. Infection and evasion.

Unit 2 Overview of diseases caused by bacteria

No. of Hours : 18

Detailed study of tuberculosis: History, causative agent, molecular basis of host specificity, infection and pathogenicity, Diagnostics, Therapeutics, inhibitors and vaccines. Drug resistance and implications on public health. Other bacterial diseases including Typhoid, Diphtheria, Pertussis, Tetanus, Typhoid and Pneumonia.

Unit 3 Overview of diseases caused by Viruses

No. of Hours : 12

Detailed study of AIDS, history, causative agent, pathogenesis, Diagnostics, Drugs and inhibitors. Other viral diseases including hepatitis, influenza, rabies, chikungunya and polio.

Unit 4 Overview of diseases caused by Parasites

No. of Hours : 8

Detailed study of Malaria, history, causative agents, Vectors, life cycle, Host parasite interactions, Diagnostics, Drugs and Inhibitors, Resistance, Vaccine development. Other diseases including leishmaniasis, amoebiasis.

Unit 5 Overview of diseases caused by other organisms

No. of Hours : 10

Fungal diseases, General characteristics. Medical importance of major groups, pathogenesis, treatment.

DSE-4 : MOLECULAR BASIS OF INFECTIOUS DISEASES (PRACTICALS)
SEMESTER – V/VI

Total Hours : 60

CREDITS: 2

1. Permanent slides of pathogens. Mycobacterium tuberculosis, Leishmania, Plasmodium falciparum
2. WIDAL test
3. Gram staining
4. Acid fast staining
4. PCR based diagnosis (Practical)
5. Dot Blot ELISA (Practical)

SUGGESTED READINGS

1. Prescott, Harley, Klein's Microbiology (2008) 7th Ed., Willey, J.M., Sherwood, L.M., Woolverton, C.J. Mc Graw Hill International Edition (New York) ISBN: 978-007-126727.

2. Mandell, Douglas and Bennett.S, Principles and practices of Infectious diseases, 7th edition, Volume, 2. Churchill Livingstone Elsevier.
3. Sherris Medical Microbiology: An Introduction to Infectious Diseases by Kenneth J. Ryan, C. George Ray, Publisher: McGraw-Hill
4. Medical Microbiology by Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller, Elsevier Health Sciences

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DSE-5 : RESEARCH PROJECT
SEMESTER – VI

Total Hours : 180

CREDITS: 6

This paper would focus on the project work / dissertation to be carried out by the students in the supervision of the teachers in the colleges. The topic of the project would be selected by each student in consultation with the teacher (Advisor). This would train the student to retrieve the literature and collate the information sufficient to make a presentation, the collated literature would also prepare the base for initiating the research. The student would carryout experiments to achieve the planned objectives, collation and analysis of data, presentation of the result in the form of a Dissertation. The grading would be based on continuous evaluation that would include punctuality, hard work, record keeping, intellectual inputs, data presentation, interpretation etc.

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DSE-6: ADVANCED CELL BIOLOGY (THEORY)
SEMESTER - VI**

Total Hours : 60

CREDITS: 4

Unit 1 Plasma Membrane and Nuclear Transport

No. of Hours : 8

Properties and Composition of Cell Membrane; Structure of Nuclear Envelope; Nuclear Pore Complex; Transport Across Nuclear Envelope; Regulation of Nuclear Protein Import and Export.

Unit 2 Cell-Cell Interaction

No. of Hours : 12

Cell-Cell Interactions and Cell-Matrix Interactions; Components of Extracellular Matrix: Collagen and Non-Collagen Components; Tight Junctions; Gap Junctions; Desmosomes; Hemidesmosomes; Focal Adhesions And Plasmodesmata; Cell Wall; Role Of Cell Interaction In Development.

Unit 3 Cell Cycle and Programmed Cell Death

No. of Hours : 16

Overview of The Cell Cycle; Eukaryotic Cell Cycle; Events Of Mitotic Phase; Cytokinesis; Events Of Meiosis And Fertilization; Regulation Of Cell Division And Cell Growth; Apoptosis And Necrosis, Stem Cells And Maintenance of Adult Tissues, Hematopoiesis, Embryonic Stem Cells and Therapeutic Cloning.

Unit 4 Cancer Biology

No. of Hours : 12

Development and causes Of Cancer; Genetic Basis of Cancer; Oncogenes, Tumor Viruses; Molecular Approach to Cancer Treatment.

Unit 5 Advanced Methods in Cell Biology

No. of Hours : 12

Ultracentrifugation, Fluorescence Microscopy- FACS, Confocal Microscopy, Electron Microscopy, Plant and Animal Cell Culture, Immunohistochemistry.

**DSE-6 : ADVANCED CELL BIOLOGY (PRACTICALS)
SEMESTER - VI**

Total Hours : 60

CREDITS: 2

1. Isolation of organelles by sub-cellular fractionation. *(Protocol)*
2. Study of cell viability / death assay by use of trypan blue and MTT assay. *or TTC (2,3,5-Triphenyl tetrazolium chloride)*
3. Study of apoptosis through analysis of DNA fragmentation patterns in mitochondria.
4. Identification and study of cancerous cells using permanent slides and photomicrographs.
5. Study of cell viability / death assay by use of trypan blue or TTC (2,3,5-Triphenyl tetrazolium chloride) and MTT assay.
6. Study of apoptosis through analysis of DNA fragmentation pattern in mitochondria.

SUGGESTED READINGS

1. Cooper, G.M. and Hausman, R.E. 2009 The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
2. Karp, G. 2010 Cell and Molecular Biology: Concepts and Experiments. 6 edition. John Wiley & Sons. Inc.
3. Alberts, B., Johnson, A., Lewis, J., and Enlarge, M. 2008 Molecular Biology of the Cell.

- 5th ed., Garland Science (Princeton),
4. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J. 2012. *Molecular Cell Biology*. 7th ed., W.H. Freeman & Company (New York),
 5. Becker, W.M., Kleinsmith, L.J., Hardin, J. and Bertoni, G. P. 2009 *The World of the Cell*. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DSE-7: PLANT BIOCHEMISTRY (THEORY)
SEMESTER – VI

Total Hours : 60

CREDITS: 4

Unit 1 Introduction to Plant cell structure

No. of Hours : 4

Plasma membrane, Vacuole and tonoplast membrane, cell wall, plastids and peroxisomes.

Unit 2 Photosynthesis and Carbon assimilation

No. of Hours : 14

Structure of PSI and PSII complexes, Light reaction, Cyclic and non cyclic photophosphorylation, Calvin cycle and regulation; C4 cycle and Crassulacean acid metabolism (CAM), Photorespiration.

Unit 3 Respiration

No. of Hours :12

Overview of glycolysis, Alternative reactions of glycolysis, Regulation of plant glycolysis, Translocation of metabolites across mitochondrial membrane, TCA cycle, Alternative NAD(P)H oxidative pathways; Cyanide resistant respiration.

Unit 4 Nitrogen metabolism

No. of Hours : 14

Biological Nitrogen fixation by free living and in symbiotic association, structure and function of enzyme Nitrogenase. Nitrate assimilation: Nitrate and Nitrite reductase. Primary and secondary ammonia assimilation in plants; ammonia assimilation by Glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway. Seed storage proteins in legumes and cereals.

Unit 5 Regulation of plant growth

No. of Hours : 4

Introduction to plant hormones and their effect on plant growth and development, Regulation of plant morphogenetic processes by light.

Unit 6 Secondary metabolites

No. of Hours : 8

Representatives alkaloid group and their amino acid precursors, function of alkaloids, Examples of major phenolic groups; simple phenylpropanoids, Coumarins, Benzoic acid derivatives, flavonoids, tannins and lignin, biological role of plant phenolics, Classification of terpenoids and representative examples from each class, biological functions of terpenoids.

Unit 6 Plant tissue culture

No. of Hours : 4

Cell and tissue culture techniques, types of cultures: organ and explants culture, callus culture, cell suspension culture and protoplast culture. Plant regeneration pathways: organogenesis and somatic embryogenesis. Applications of cell and tissue culture and somoclonal variation.

DSE-7: PLANT BIOCHEMISTRY (PRACTICALS)
SEMESTER – VI

Total Hours : 60

CREDITS: 2

1. Induction of hydrolytic enzymes proteinases /amylases/lipase during germination
2. Extraction and assay of Urease from Jack bean
3. Estimation of carotene/ascorbic acid/phenols/tannins in fruits and vegetables
4. Separation of photosynthetic pigments by TLC
5. Culture of plant plants (explants).

SUGGESTED READINGS

1. Plant Biochemistry (2008), Caroline Bowsher, Martin steer, Alyson Tobin, Garland science ISBN 978-0-8153-4121-5
2. Biochemistry and molecular Biology of plant-Buchanan. (2005) 1 edition, Publisher: I K International. ISBN-10: 8188237116, ISBN-13: 978-8188237111.
3. Plant Biochemistry by P.M Dey and J.B. Harborne (Editors) (1997) Publisher: Academic Press ISBN-10:0122146743, ISBN-13:978-0122146749

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DSE-8: RESEARCH METHODOLOGY
SEMESTER – VI

Total Hours : 20 hrs Theory and 140 hrs Practical **CREDITS: 6**

Unit 1 Introduction to Research Methodology **No. of Hours : 4**
Objectives and motivation in research.

Unit 2 Defining the Research Problem **No. of Hours : 4**
Selecting and defining a research problem, Reviewing and conducting literature search, Developing a research plan.

Unit 3 Designing of Experiment **No. of Hours : 4**
Different experimental designs – single and multifactorial design, Making measurements and sources of error in measurements, Methods of data collection and record keeping.

Unit 4 Data Processing and Statistical Analysis **No. of Hours : 8**
Processing operations, tabulation, and graphical representation, Statistics in research: Concepts of sample and population, Measure of central tendency, dispersion, asymmetry (skewness, kurtosis), Normal distribution (p-value), Statistical tests and hypothesis (Standard error, t-test, chi-square test), and regression analysis, Report writing, Writing a research paper - abstract, introduction, methodology, results and discussion.

Based on the teaching above, each student will undertake the following exercises.

1. A teacher (adviser) who would guide the student will discuss with student and identify a topic of mutual interest.
2. The student will collect the literature, collate the information and write the same in the form of a term paper with proper incorporation of references using appropriate software such as EndNote.
3. The student will identify scope of research on the topic and will frame objectives to be addressed in the project through a work plan.
4. The student will write standard operating protocols (SOPs) and identify requirement for equipment and reagents.
5. Each student will be asked to make presentation about the project including literature available, objective sought and work plan including methodologies as described above.

SUGGESTED READINGS

1. Research in Education (1992) 6th ed., Best, J.W. and Kahn, J.V., Prentice Hall of India Pvt. Ltd.
2. At the Bench: A Laboratory Navigator (2005) Barker, K., Cold Spring Harbor Laboratory Press (New York), ISBN: 978-087969708-2.

3. Research Methodology - Methods and Techniques (2004) 2nd ed., Kothari C.R., New Age International Publishers.
4. Research Methodology: A Step by Step Guide for Beginners (2005) 2nd ed., Kumar R., Pearson Education.
5. Biostatistics: A Foundation for Analysis in the Health Sciences (2009) 9th ed., Daniel W.W., John Wiley and Sons Inc.
6. Statistics at the Bench: A Step-by-Step Handbook for Biologists (2010) Bremer, M. and Doerge, R.W., Cold Spring Harbor Laboratory Press (New York), ISBN: 978-0-879698-57-7.

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVES**

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GE-1 : BIOCHEMISTRY OF CELL (THEORY)
SEMESTER - I**

TOTAL HOURS : 60

CREDITS: 4

Unit 1 Biomolecules in their cellular environment

No. of Hours : 6

The cellular basis of life. Cellular structures – prokaryotes and eukaryotes. Chemical principles in biomolecular structure. Major classes of biomolecules. Role of water in design of biomolecules.

Unit 2 Amino acids and peptides

No. of Hours : 10

Types of amino acids and their chemistry, derivatives of amino acids and their biological role. Introduction to biologically important peptides.

Unit 3 Sugars and polysaccharides

No. of Hours : 10

Basic chemistry of sugars, optical activity. Disaccharides, trisaccharides and polysaccharides - their distribution and biological role.

Unit 4 Nucleosides, nucleotides and nucleic acids

No. of Hours : 10

Structures and chemistry, DNA structures and their importance, different types of RNA. Unusual DNA structures, other functions of nucleotides.

Unit 5 Lipids

No. of Hours : 10

Various classes of lipids and their distribution, storage lipids, structural lipids in membranes, lipids as signals, cofactors and pigments.

Unit 6 Vitamins, coenzymes and metal ions

No. of Hours : 8

Occurrence and nutritional role. Coenzymes and their role in metabolism. Metal ion containing biomolecules - heme, porphyrins and cyanocobalamin; their biological significance.

Unit 7 Signalling molecules

No. of Hours : 6

Second messengers - cAMP, cGMP, IP₃, diacyl glycerol, Ca²⁺, NO. Brief account of their importance and role in signalling and signal transduction.

**GE-1 : BIOCHEMISTRY OF CELL (PRACTICALS)
SEMESTER - I**

TOTAL HOURS : 60

CREDITS: 2

1. General safety procedures in a laboratory. Use of auto pipettes. Making solutions and buffer preparation - acetate and tris buffers.
2. Qualitative tests for biomolecules - carbohydrates, lipids, amino acids, proteins, bases and nucleic acids.
3. Separation of amino acids by paper chromatography.
4. Separation of sugars/bases by TLC and their identification.
5. Estimation of ascorbic acid in fruit juices.

SUGGESTED READINGS

6. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13; 978-1-4641-0962-1 / ISBN:10-14641-0962-1.
7. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN:978-0-470-28173-4.

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GE-2 : PROTEINS AND ENZYMES (THEORY)
SEMESTER – II**

Total Hours : 60

CREDITS: 4

Unit 1 Introduction to proteins

No. of Hours : 4

Polypeptides and proteins. Subunit structures, conjugated proteins, diversity of function.

Unit 2 Isolation and analysis of proteins

No. of Hours : 12

Techniques to isolate and analyze proteins- salt fractionation, ion-exchange chromatography, gel permeation, HPLC, SDS-PAGE, IEF. Protein primary structure - sequencing by Edman degradation, use of enzymes and chemical reagents to obtain overlap peptides. Synthesis of peptides using Merrifield method.

Unit 3 Introduction to protein three-dimensional structures

No. of Hours : 10

Secondary structure- helices and sheets, Ramachandran maps. Nature of non-covalent bonds and covalent bonds in protein folding. Tertiary and quaternary structures.

Unit 4 Myoglobin and haemoglobin - structure and function

No. of Hours : 4

Oxygen binding curves, cooperativity models for haemoglobin.

Unit 5 Introduction to enzyme catalysis

No. of Hours : 8

Features of enzyme catalysis, superior catalytic power. General mechanisms of catalysis. Nomenclature.

Unit 6 Enzyme kinetics

No. of Hours : 10

Principles of reaction rates, order of reactions and equilibrium constants. Derivation of Michaelis-Menten equation. Significance of K_m and V_{max} . Catalytic efficiency parameters. Competitive and mixed inhibitions. Kinetics and diagnostic plots. Types of irreversible inhibitors.

Unit 7 Mechanisms of enzyme action and regulation

No. of Hours : 6

Mechanism of action of chymotrypsin. Inhibitors of enzymes - antibiotics. Regulation of enzyme activity and its importance - aspartate transcarbamoylase.

Unit 8 Enzymes in medicine and industry

No. of Hours : 6

Enzymes used in clinical biochemistry as reagents, diagnostics and therapy. Role of immobilized enzymes in industry.

GE-2 : PROTEINS AND ENZYMES (PRACTICALS)
SEMESTER – II

Total Hours : 60

CREDITS: 2

8. Protein estimation by UV absorbance and Biuret method.
9. Protein microassay by Lowry/Bradford method.
10. Ammonium sulphate fractionation of crude homogenate from germinated mung bean.
11. Setting up assay for acid phosphatase and activity measurements of the ammonium sulphate fractions (progress curve and effect of pH).
12. Determination of K_m and V_{max} of enzyme enriched fraction.
13. Inhibition of acid phosphatase activity by inorganic phosphate.

SUGGESTED READINGS

3. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13: 978-1-4641-0962-1 / ISBN:10-14641-0962-1.
4. Fundamentals of Enzymology (1999) 3rd ed., Price, N.C and Stevens, L., Oxford University Press Inc., (New York), ISBN:13: 978-0-19-806439-8.

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GE-3 : INTERMEDIARY METABOLISM (THEORY)
SEMESTER - III**

Total Hours : 60

CREDITS: 4

Unit 1 Basic concepts and design of metabolism

No. of Hours : 4

The nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency.

Unit 2 Glycolysis and gluconeogenesis

No. of Hours : 6

Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis.

Unit 3 The citric acid cycle

No. of Hours : 6

Pyruvate dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway.

Unit 4 Oxidative phosphorylation

No. of Hours : 6

The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3-phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.

Unit 5 Photosynthesis, Calvin cycle and pentose phosphate pathway

No. of Hours : 8

The light reaction, chlorophyll, accessory pigments, reaction centres, two photo systems, generation of proton gradient and NADPH, Calvin cycle, synthesis of glucose, starch, sucrose, regulation, C₄ pathway. Pentose phosphate pathway, importance and regulation.

Unit 6 Glycogen metabolism

No. of Hours : 6

Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis.

Unit 7 Fatty acid synthesis and degradation

No. of Hours : 6

TAG as energy source, β oxidation of fatty acids in mitochondria and peroxisomes, ketone bodies. Biosynthesis of fatty acids - elongation and unsaturation of fatty acids. Regulation of fatty acid oxidation and synthesis.

Unit 8 Amino acid catabolism and anabolism

No. of Hours : 6

Protein degradation to amino acids, urea cycle, feeder pathways into TCA cycle. Nitrogen fixation, synthesis of non-essential amino acids.

Unit 9 Nucleotide metabolism

No. of Hours : 6

Biosynthesis - *de novo* and salvage pathways, regulation of nucleotide synthesis by feedback inhibition, degradation and excretion.

Unit 10 Integration of metabolism

No. of Hours : 6

Brief role of hormones - catecholamines, insulin, glucagon; metabolic shifts to provide fuel to brain during fasting and starvation, role of cortisol in signalling stress - increase in gluconeogenesis and muscle protein breakdown.

GE-3 : INTERMEDIARY METABOLISM (PRACTICALS)
SEMESTER - III

Total Hours : 60

CREDITS: 2

1. Alcohol fermentation by yeast. (Antisept)
2. H₂S production, indole production and ammonia production by bacteria.
3. Urea estimation.
4. Uric acid estimation.
5. Nitrogen fixation by cyanobacteria. (Bread like)

SUGGESTED READINGS

1. Biochemistry (2012) 7th ed., Campbell, M.K. and Farrel, S.O. Brooks/Cole, Cengage Learning (Boston), ISBN: 13:978-1-111-42564-7.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GE-4 : GENE ORGANIZATION, EXPRESSION AND REGULATION
(THEORY)
SEMESTER - IV

Total Hours : 60

CREDITS: 4

Unit 1 Structure of genes and chromosomes

No. of Hours : 8

Definition of a gene, chromosomal organization of genes in viruses, bacteria and eukaryotes. Supercoiling of DNA.

Unit 2 Replication of genomes

No. of Hours : 12

General features of DNA replication, properties of prokaryotic and eukaryotic DNA polymerases. Replication of DNA and telomeres in linear chromosomes. Replication of RNA genomes.

Unit 3 Recombination of DNA

No. of Hours : 4

Homologous genetic recombination, Holliday model, proteins and enzymes mediating recombination.

Unit 4 Gene mutations and repair

No. of Hours : 6

Molecular basis of mutations, multiple repair systems, mismatch repair, base excision repair, nucleotide excision repair, direct repair and translesion DNA synthesis.

Unit 5 Transcription of genes

No. of Hours : 10

General features of gene transcription, prokaryotic and eukaryotic RNA polymerases, stages of transcription, initiation, elongation and termination. Inhibitors of transcription.

Unit 6 RNA processing

No. of Hours : 4

Processing of eukaryotic mRNA, splicing of introns, alternate splicing and editing, ribosomal and tRNA processing.

Unit 7 Protein synthesis

No. of Hours : 10

Features of the genetic code, amino acylation of tRNAs, structure and assembly of ribosomes; three stages of protein synthesis - initiation, elongation and termination. Inhibitors of protein synthesis.

Unit 8 Regulation of gene expression

No. of Hours : 6

Regulation of transcription in prokaryotes, concept of operons. Lac operon - control by negative and positive regulatory proteins, Trp operon - control by attenuation. Regulation of transcription in eukaryotes, regulatory sequences - enhancers, silencers response elements, nucleosome alterations, DNA-protein interactions and RNA interference.

**GE-4 : GENE ORGANIZATION, EXPRESSION AND REGULATION
(PRACTICALS)
SEMESTER - IV**

Total Hours : 60

CREDITS: 2

1. Quantitative determination of DNA and RNA by absorbance at 260 nm and using A_{260}/A_{280} ratio to distinguish between them.
2. To study the viscosity of DNA solutions.
3. Isolation of chromosomal DNA from *E. coli*.
4. Isolation of total RNA from yeast cells. (Primer))

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13; 978-1-4641-0962-1 / ISBN:10-14641-0962-1.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GE-5 : FUNDAMENTALS OF CELL BIOLOGY AND IMMUNOLOGY
(THEORY)
SEMESTER - IV

Total Hours : 60

CREDITS: 4

Unit 1 Cells and organelles

No. of Hours : 6

Prokaryotic and eukaryotic cells. Plasma membrane, the nucleus, intracellular membranes and organelles, mitochondria, chloroplast, endoplasmic reticulum, Golgi complex, lysosome, peroxisome, cytoskeleton, extracellular matrix, cell wall. Mitosis and meiosis.

Unit 2 Membrane structure and function

No. of Hours : 8

Composition of membranes, membrane lipids, membrane proteins, isolation and characterization. Integral, peripheral and lipid anchored protein. Transport across membranes, simple and facilitated diffusion, active transport.

Unit 3 Endoplasmic reticulum and Golgi complex

No. of Hours : 6

The two types of endoplasmic reticulum, rough and smooth. The Golgi complex. Role of Golgi in protein glycosylation and protein trafficking.

Unit 4 Signalling mechanisms, messengers and receptors

No. of Hours : 8

Chemical signals and cellular receptors. G-protein linked receptors, protein kinase associated receptors. Hormonal signalling, cell signals and apoptosis.

Unit 5 Cell cycle and its regulation

No. of Hours : 4

Overview of the cell cycle. Regulation of the cell cycle, cyclin dependent kinases.

Unit 6 Overview of the immune system

No. of Hours : 4

Self versus nonself. Humoral and cellular immunity. Innate and adaptive immunity. Cells of the immune system, primary and secondary lymphoid tissues and organs. Cellular and humoral responses.

Unit 7 Innate immunity

No. of Hours : 8

Defensins. Non-immunological barriers. Cells and soluble mediators of innate immunity. Acute phase proteins. Cytokines. Complement system.

Unit 8 Humoral B cell response

No. of Hours : 8

Structure of antibodies, types of immunoglobulins, generation of antibody diversity, B cell activation, theory of clonal selection, formation of plasma and memory cells; T-independent B-response; antigens, haptens carriers and adjuvants.

Unit 9 Cell mediated immunity

No. of Hours : 8

T-cell development, MHC locus. Structure, function and distribution of MHC glycoproteins. Antigen processing and presentation. Cell mediated immune responses by different T-cell sub populations. Hypersensitive reactions. Concept of autoimmunity.

**GE-5 : FUNDAMENTALS OF CELL BIOLOGY AND IMMUNOLOGY
(PRACTICALS)
SEMESTER - IV**

Total Hours : 60

CREDITS: 4

1. Visualization of animal and plant cell by methylene blue.
2. Identification of different stages of mitosis in onion root tip.
3. Isolation of organelles by sub-cellular fractionation. (Handwritten)
4. Isolation of IgG from serum by ion exchange chromatography. (Handwritten)
5. Antigen-antibody interaction by Ouchterlony double diffusion. (Handwritten)

SUGGESTED READINGS

2. The World of the Cell (2009), 7th ed., Becker W.M., Kleinsmith, L.J., Hardin, J., Bertoni, and G.P., Pearson Benjamin Cummings (CA), ISBN: 978-0-321-55418-5.
3. Prescott, Harley, Klein's Microbiology (2008) 7th Ed., Willey, J.M., Sherwood, L.M., Woolverton, C.J. Mc Graw Hill International Edition (New York) ISBN: 978-007-126727.
4. Molecular Cell Biology (2013) 7th Ed., Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Scott, M.P., Macmillan International Edition (New York), ISBN:13: 978-1-4641-0981-2.
5. Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A., W.H Freeman and Company (New York), ISBN:13: 978-0-7167-8590-3 / ISBN: 10:0-7617-8590-0.
6. Immunology: A Short Course (2009) 6th ed., Coico, R and Sunshine, G., John Wiley & sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GE-6 : FUNDAMENTALS OF GENETIC ENGINEERING (THEORY)
SEMESTER - IV

Total Hours : 60

CREDITS: 4

Unit 1 Introduction to recombinant DNA technology

No. of Hours : 8

Overview of recombinant DNA technology. Plasmids and bacteriophage DNA as cloning vectors, pBR322, pUC8. Purification of plasmid and bacteriophage DNA. Enzymes used in manipulating DNA, separation by electrophoresis.

Unit 2 Cloning vectors for prokaryotes and eukaryotes

No. of Hours : 12

Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors based on *E. coli* plasmids, pBR322, pUC8, pGEM3Z. Cloning vectors based on M13 and λ bacteriophage. Vectors for yeast, higher plants and animals.

Unit 3 Construction, selection and identification of recombinants

No. of Hours : 12

Ligation of DNA molecules. Transformation and electroporation, selection for transformed cells. Identification for recombinants, blue-white selection. Identification of recombinant phages. Direct selection, marker rescue. Gene libraries. Identification of a clone from gene library, colony and plaque hybridization probing, methods based on detection of the translation product of the cloned gene.

Unit 4 Polymerase chain reaction and DNA sequencing

No. of Hours : 8

Fundamentals of polymerase chain reaction, designing primers for PCR. Analysis of PCR products. DNA sequencing by Sanger's method and automated DNA sequencing.

Unit 5 Expression of cloned genes

No. of Hours : 10

Vectors for expression of foreign genes in *E. coli*, cassettes and gene fusions. Challenges in producing recombinant protein in *E. coli*. Production of recombinant protein by eukaryotic cells. Fusion tags and their role in purification of recombinant proteins.

Unit 6 Applications of genetic engineering in biotechnology

No. of Hours : 10

Expression of cloned genes. Vectors for expression of foreign genes in *E. coli*, cassettes and gene fusions. Production of recombinant pharmaceuticals such as insulin. Gene therapy. Genetically modified plants such as herbicide resistant crops.

GE-6 : FUNDAMENTALS OF GENETIC ENGINEERING (PRACTICALS)
SEMESTER – IV

Total Hours : 60

CREDITS: 4

1. Ultraviolet absorption spectrum of DNA and RNA.
2. Isolation of plasmid DNA and restriction digestion.
3. Amplification of a DNA fragment by PCR (Practical)
4. Virtual lab exercise on recombinant DNA techniques. (Practical)

SUGGESTED READINGS

1. Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York), ISBN:0-321-50781 / ISBN: 978-0-321-50781-5.
2. Gene Cloning and DNA Analysis (2010) 6th ed., Brown, T.A., Wiley-Blackwell Publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
3. Principles of Gene Manipulation and Genomics (2006) 7th ed., Primrose, S. B., and Twyman, R. M., Blackwell publishing (Oxford) ISBN: 13: 978-1-4051-3544-3.
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) 4th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC), ISBN: 978-1-55581-498-4 (HC).

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GE-7 : BIOCHEMICAL CORRELATIONS IN DISEASES (THEORY)
SEMESTER - IV

Total Hours : 60

CREDITS: 4

Unit 1 Inborn errors of metabolism

No. of Hours : 8

Alkaptonuria, Phenylketonuria, Glycogen and Lipid storage diseases, SCID, Clotting disorders.

Unit 2 Nutritional deficiency based diseases

No. of Hours : 8

Kwashiorkar, Marasmus, Beri-beri, Scurvy, Pellagra, Anaemia, Night blindness, Rickets, Osteomalacia, Osteoporosis, Wilson's disease.

Unit 3 Life style diseases

No. of Hours : 8

Obesity, Cardiovascular diseases, Atherosclerosis, Diabetes mellitus-II. Inflammatory Bowel Disease (IBD).

Unit 4 Hormonal Imbalances

No. of Hours : 8

Outline of hormone action and imbalances leading to disease - precocious puberty, hyper and hypopituitarism. Hyper and hypothyroidism.

Unit 5 Autoimmune diseases

No. of Hours : 6

Concepts in immune recognition - self and non self discrimination, organ specific autoimmune diseases - Hashimoto's thyroiditis, Grave's disease, myasthenia gravis; Systemic diseases - SLE, rheumatoid arthritis; Diabetes Mellitus-I.

Unit 6 Diseases caused due to misfolded proteins

No. of Hours : 8

Alzheimer's, Huntington's disease, Kuru, Creutzfeldt-Jakob disease, Sickle cell anaemia, Thalessemia.

Unit 7 Infectious diseases

No. of Hours : 16

Viral infection (polio, measles, mumps, influenza, HIV); Bacterial infections (tetanus, diphtheria, tuberculosis, typhoid, cholera); Protozoan (*Plasmodium* and *Trypanosoma*) and parasitic infections. Vaccines against diseases. General strategies in the design and development of vaccines.

GE-7 : BIOCHEMICAL CORRELATIONS IN DISEASES (PRACTICALS)
SEMESTER - IV

Total Hours : 60

CREDITS: 2

1. Glucose tolerance test.
2. Lipid profile: triglycerides and total cholesterol.
3. Obesity parameters.
4. RBC counting and haemoglobin estimation.
5. Blood pressure measurements.
6. Bone density measurements (visit to a nearby clinic).
7. T₄/TSH assays (Practical)

SUGGESTED READINGS

1. Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
2. Immunology: A Short Course (2009) 6th ed., Coico, R and Sunshine, G., John Wiley & sons, Inc (New Jersey), ISBN: 978-0-470-08158-7
3. Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer, L., W.H Freeman and Company (New York), ISBN: 13:978-1-4292-7635-1.
4. Genetics (2012) 6th ed., Snustad, D.P. and Simmons, M.J., John Wiley & Sons. (Singapore), ISBN: 978-1-118-09242-2.

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT COURSES**

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SEC-1 : TOOLS AND TECHNIQUES IN BIOCHEMISTRY
SEMESTER – III**

TOTAL HOURS : 30

CREDITS : 2

Unit 1 Biochemical reagents and solutions

No. of Hours: 18

Safety practices in the laboratory. Preparation and storage of solutions. Concepts of solution concentration and storing solutions. Quantitative transfer of liquids. Concept of a buffer, Henderson-Hasselbach equation, working of a pH meter.

Exercise

- Preparation of a buffer of given pH and molarity.

Unit 2 Spectrophotometric techniques

No. of Hours : 6

Principle and instrumentation of UV-visible and fluorescence spectroscopy.

Exercises

- Determination of the absorption maxima and molar extinction coefficient (of a relevant organic molecule).
- Measurement of fluorescence spectrum.
- Determination of concentration of a protein solution by Lowry/BCA method.

Unit 3 Introduction and importance of virtual labs in biochemistry

No. of Hours: 6

SUGGESTED READINGS

1. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN:978-0-470-85602-4 / ISBN:978-0-470-85603-1.
2. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder, D., W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.
3. An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN:13: 978-0-07-099487-4 / ISBN:10: 0-07-099487-0.

**B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SEC-2 : PROTEIN PURIFICATION TECHNIQUES
SEMESTER – III**

TOTAL HOURS : 30

CREDITS: 2

Unit 1 Purification and characterization of a protein from a complex mixture (native or heterologously expressed) involving the following methods/techniques

No. of Hours : 24

Exercises

- Preparation of the sample.
- Ion-exchange chromatography.
- Gel filtration chromatography.
- Affinity chromatography.
- Electrophoresis.

Unit 2 Demonstration of High Performance Liquid Chromatography (HPLC)

No. of Hours : 6

SUGGESTED READINGS

1. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN:978-0-470-85602-4 / ISBN:978-0-470-85603-1.
2. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder, D., W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.
3. An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN:13: 978-0-07-099487-4 / ISBN:10: 0-07-099487-0.

B.Sc. (HONS) BIOCHEMISTRY (CBCS STRUCTURE)
SEC-3 : CLINICAL BIOCHEMISTRY
SEMESTER – III

TOTAL HOURS : 30

CREDITS: 2

Unit 1 Introduction

No. of Hours: 4

Organization of clinical laboratory, Introduction to instrumentation and automation in clinical biochemistry laboratories safety regulations and first aid. General comments on specimen collection, types of specimen for biochemical analysis. Precision, accuracy, quality control, precautions and limitations.

Exercises

- Collection of blood and storage.
- Separation and storage of serum.

Unit 2 Evaluation of biochemical changes in diseases

No. of Hours: 4

Basic hepatic, renal and cardiovascular physiology. Biochemical symptoms associated with disease and their evaluation. Diagnostic biochemical profile.

Unit 3 Assessment of glucose metabolism in blood

No. of Hours: 4

Clinical significance of variations in blood glucose. Diabetes mellitus.

Exercises

- Estimation of blood glucose by glucose oxidase peroxidase method.

Unit 4 Lipid profile

No. of Hours: 4

Composition and functions of lipoproteins. Clinical significance of elevated lipoprotein.

Exercises

- Estimation of triglycerides.

Unit 5 Liver function tests

No. of Hours : 4

Exercises

- Estimation of bilirubin (direct and indirect).

Unit 6 Renal function tests and urine analysis

No. of Hours : 6

Use of urine strip / dipstick method for urine analysis.

Exercises

- Quantitative determination of serum creatinine and urea.

Unit 7 Tests for cardiovascular diseases

No. of Hours : 4

Involvement of enzymes in diagnostics of heart disease including aspartate transaminase, isoenzymes of creatine kinase and lactate dehydrogenase and troponin.

Exercises

- Estimation of creatine kinase MB.

SUGGESTED READINGS

1. Medical Laboratory Technology - a Procedure Manual for Routine Diagnostic Tests Vol. I (2010), Mukherjee, K.L., Tata Mc Graw-Hill Publishing Company Limited (New Delhi). ISBN:9780070076594 / ISBN:9780070076631
2. Medical Laboratory Technology - a Procedure Manual for Routine Diagnostic Tests Vol. II (2010), Mukherjee, K.L., Tata Mc Graw - Hill Publishing Company Ltd. (New Delhi), ISBN: 9780070076648.
3. Medical Biochemistry (2005) 2nd ed., Baynes, J.W. and Dominiczak, M.H., Elsevier Mosby Ltd. (Philadelphia), ISBN:0-7234-3341-0.
4. Experimental Biochemistry: A Student Companion (2005) Rao, B.S. and Deshpande, V., IK International Pvt. Ltd. (New Delhi), ISBN:81-88237-41-8.

**B.Sc. (HONS) BIOCHEMISTRY (CBCS STRUCTURE)
SEC-4 : BIOINFORMATICS
SEMESTER - IV**

TOTAL HOURS : 30

CREDITS: 4

Unit 1 Introduction to bioinformatics

No. of Hours : 4

Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - genomics, proteomics, computer aided drug design (structure based and ligand based approaches) and Systems Biology. Applications of bioinformatics.

Unit 2 Biological databases and data retrieval

No. of Hours : 8

Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Structure viewers (Ras Mol, J mol), file formats.

Exercises

- Sequence retrieval (protein and gene) from NCBI.
- Structure download (protein and DNA) from PDB.
- Molecular file formats - FASTA, GenBank, Genpept, GCG, CLUSTAL, Swiss-Prot, FIR.
- Molecular viewer by visualization software.

Unit 3 Sequence alignment

No. of Hours : 3

Similarity, identity and homology. Alignment – local and global alignment, pairwise and multiple sequence alignments, alignment algorithms, amino acid substitution matrices (PAM and BLOSUM), BLAST and CLUSTALW.

Exercises

- BLAST suite of tools for pairwise alignment.
- Multiple sequence alignment using CLUSTALW.

Unit 4 Phylogenetic analysis

No. of Hours : 3

Construction of phylogenetic tree, dendrograms, methods of construction of phylogenetic trees - maximum parsimony, maximum likelihood and distance methods.

Exercise

- Generating phylogenetic tree using PHYLIP.

Unit 5 Protein structure prediction and analysis

No. of Hours : 6

Levels of protein structure. Protein tertiary structure prediction methods - homology modeling, fold recognition and *ab-initio* methods. Significance of Ramachandran map.

Exercises

- Primary sequence analyses (Protparam).
- Secondary structure prediction (GOR, nnPredict).
- Tertiary structure prediction (SWISSMODEL).
- Protein structure evaluation - Ramachandran map (PROCHECK).

Unit 6 Genomics

No. of Hours : 6

Introduction to genomics, comparative and functional genomics, gene structure in prokaryotes and eukaryotes, gene prediction methods and tools.

Exercise

- Gene prediction using GENSCAN and GLIMMER.

SUGGESTED READINGS

1. Bioinformatics: Sequence and Genome Analysis (2001), 1st ed., Mount, D.W. Cold Spring Harbor Laborator Press (New York), ISBN: 0-87969-608-7.
2. Bioinformatics and Functional Genomics (2003), 1st ed., Pevsner, J., John Wiley & Sons, Inc. (New Jersey), ISBN: 0-47121004-8.
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (2005), 3rd ed., Baxevanis, A.D. and Ouellette, B.F., John Wiley & Sons, Inc. (New Jersey), ISBN: 0-47147878-4.
4. Bioinformatics – Principles and Applications (2008), 1st ed. Ghosh, Z. and Mallick, B., Oxford University Press (India), ISBN: 9780195692303.

B.Sc. (HONS) BIOCHEMISTRY (CBCS STRUCTURE)
SEC-5 : RECOMBINANT DNA TECHNOLOGY
SEMESTER - IV

TOTAL HOURS : 30

CREDITS: 2

Unit 1 Work flow for *in silico* cloning

No. of Hours : 2

Unit 2 Preparation of media, antibiotic solution, culturing of *E. coli*, isolation of single colonies

No. of Hours : 6

Exercises

- Preparation of LB broth and agar.
- Inoculation of medium.
- Preparation of glycerol stocks of bacterial strains.
- Obtaining isolated colonies by streak plate method.
- Preparation of stock solutions.

Unit 3 Overview of plasmid vectors and methods of isolation **No. of Hours : 8**

Exercises

- Isolation of plasmid by alkaline lysis method.
- Isolation of plasmid DNA using column chromatography (kit).

Unit 4 Characterization of plasmid by gel electrophoresis **No. of Hours : 2**

Exercise

- Digestion of plasmid DNA with restriction enzymes and analysis of the fragments.

Unit 5 Cloning of a gene in a vector and functional analysis **No. of Hours : 12**


Polymerases chain reaction (parametric optimization, primer designing), ligation, introduction of DNA construct into host cells, selection of recombinants.

Exercises

- Amplification of DNA segment/gene of interest by PCR.
- Purification of PCR product, digestion of insert and vector by restriction enzymes for directional cloning, purification of insert and digested vector by gel extraction.
- Ligation of vector and insert.
- Preparation of competent cells of *E. coli* DH5a and transformation with the ligation mixture.
- Functional selection of recombinants (blue/white selection and eGFP fluorescence).

SUGGESTED READINGS

1. Molecular Cloning: A laboratory Manual (2012) Vol. 1-3, 4th ed., Green M.R. and Sambrook J., Cold Spring Harbour Laboratory Press (New York). ISBN: 978-1-936113-41-5 / ISBN: 978-1-936113-42-2.


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