Mahatma Gandhi University, Nalgonda.
University College of Science, Department of Biochemistry
M.Sc. Biochemistry CBCS Schema (with effect from 2023-24 A.Y. admitted batch)

	SEMESTER- I				
PAPERS	Subject title with code	Workload/week	Credits	Internal exam marks+ Assignment & / Seminars	Final exam marks
1	BI101T: Chemistry and Metabolism of Proteins, Lipids and Porphyrins (core)	4	4	20+10	70
2	BI102T: Chemistry and Metabolism of Carbohydrates, Nucleic Acids and Vitamins (core)	4	4	20+10	70
3	BI 103T: Bioanalytical Techniques (core)	4	4	20+10	70
4	BI104T: Bioenergetics and Cell Biology (core)	4	4	20+10	70
5	BI105P: Analysis of Biomolecules and Biochemical preparations	6 (+6@)	3	--	75
6	BI106P: Bioanalytical Techniques	6 (+6@)	3	--	75
	Total	28 (+12@)	22	120	430
	SEMESTER- II				
PAPERS	Subject title with code	Workload/week	Credits	Internal exam marks+ Assignment & / Seminars	Final exam marks
1	BI201T: Enzymology (core)	4	4	20+10	70
2	BI202T: Molecular Biology (core)	4	4	20+10	70
3	BI203T: Biochemical Genetics and Model Organisms (core)	4	4	20+10	70
4	BI 204T: Endocrinology and Metabolic Disorders (core)	4	4	20+10	70
	Add on paper	2	2	10+5	35
5	BI205P: Enzymology and Genetics	6 (+6@)	3	--	75
6	BI206P: Molecular Biology and Endocrinology	6 (+6@)	3	--	75
	Total	30 (+12@)	24	135	465
	SEMESTER -III				
PAPERS	Subject title with code	Workload/week	credits	Internal exam marks+ Assignment & / Seminars	Final exam marks
1	BI301T: Gene Regulation and Genetic Engineering (core)	4	4	20+10	70
2	BI302T: Immunology and Immunotechnology (core)	4	4	20+10	70
3	BI303T:**A**-Clinical Biochemistry/**B**-Nutrition(optional)	3(+3$)	3	25	50
4	BI304T:**A**-Human Physiology and Xenobiotics/**B**-Neurobiochemistry (optional)	3(+3$)	3	25	50
	#Inter Disciplinary paper (ID paper) Biomolecules & Basics in Nutrition	2	2	10+5	35
5	BI305P: Recombinant DNA and Immunotechnology	6 (+6@)	3	--	75
6	BI306P: Nutrition and Clinical Biochemistry	6 (+6@)	3	--	75
	Total	28 (+6$) (+12@)	22	125	425
	SEMESTER -IV				
PAPERS	Subject title with code	Workload/ week	Credits	Internal exam marks+ Assignment & / Seminars	Final exam marks
1	BI401T: Biostatistics and Bioinformatics (core)	4	4	20+10	70
2	BI402T: Cell-Cell Communication and Signal Transduction (core)	4	4	20+10	70
3	BI403T: **A**-Microbiology/**B**-Bionanotechnology (optional)	3(+3$)	3	25	50
4	BI404T: **A**-Biotechnology/**B**-Biochemical Pharmacology and Toxicology (optional)	3(+3$)	3	25	50
5	BI405P: Bioinformatics and Biostatistics	6 (+6@)	3	--	75
6	BI 406 P: Microbiology and Biotechnology	6 (+6@)	3	--	75
7	BI 407: Project	%	4	--	100
	Total	26 (+12@)	24	110	490

	Sem-I	Sem-II	Sem-III	Sem-IV	Total
No. of credits	22	24	22	24	92
Marks	550	600	550	600	2300
Total work load of Sem-I & Sem-III					*54 (+6$) (+24@)
Total work load of Sem-II & Sem-IV					*54 (+6$) (+24@)

Note: *Work load without Add on and ID papers; #ID paper is offered by Dept. of Biochemistry and can be opted by other course students (not for M.Sc. Biochemistry course students); @ batches are made for practicals, if student number increases more than 20; $=if two optionals are opted by different group of students; %1hr/week workload for handling project work (individual/group) per faculty.

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NALGONDA-508 254. (T.S.)

Semester-I

Paper-I: BI 101T: Chemistry and Metabolism of Proteins, Lipids and Porphyrins (Core, 4 Credits; 100 Marks)

Unit–I: Chemistry of Amino acids & Proteins

1. Classification and structure of 20 amino acids, Essential, Non–essential,unusual/non-protein amino acids
2. General properties of Amino acids, acid–base titration of amino acids, pKa value.
3. Peptide bond–formation and stability, Primary structure,
4. Secondary structures and motifs: α-helix, β-sheet, 310-helix, Ramachandran plot
5. Leucine zipper, Zinc finger,Trans-membrane domain, bHLH
6. Tertiary & Quaternary structure (Myoglobin, Hemoglobin)
7. Protein-protein interactions (Actin, Tubulin)
8. Small peptides (Glutathione, Peptide Hormones), Cyclic peptides (Gramicidin)
9. Classification of proteins-Globular, Fibrous, Membrane, Metalloproteins, SCOP, CATH
10. Denaturation (pH, Temperature, Chaotropic agents), Refolding, Role of chaperones in folding.

Unit–II: Metabolism of Amino acids & Proteins

1. Metabolic fate of dietary proteins and Amino acids
2. Degradations to glucose and ketone bodies
3. Aminoacids degraded to Pyruvate, Oxaloacetate
4. Aminoacids degraded to Acetyl-CoA, Succinyl-CoA
5. Metabolism of branched chain amino acids
6. Role of glutamate cycle in formation & circulation of ammonia
7. Glucose Alanine cycle, Urea cycle
8. Linking of Citric acid and Urea cycles, regulation of urea cycle
9. Genetic defects in metabolism of aminoacids (Albinism, Phenyl ketonuria, Maple syrup urine disease, Homocystinuria, Alkaptonuria, Methyl malonic Acidemia)
10. Genetic defects in metabolism of Urea (Argininemia,Arignosuccinic Acidemia, Carbamoyl Phosphate Synthetase-I deficiency)

Unit–III: Chemistry of Lipids & Porphyrins

1. Classification & biological significance of lipids & fatty acids
2. Steroids, Sterols, relation to vitamin-D and steroid hormones
3. Bile acids and salts, Phospho lipids
4. Oils, waxes, Isoprene units
5. Lipoproteins
6. Glycolipids, Sphing lipids
7. Structure & function of porphyrins (e.g.Heme, Chlorophyll)
8. Cerebrosides, Gangliosides
9. Prostaglandins, Prostacyclins
10. Thromboxanes, Leukotrienes

Unit–IV: Metabolism of Lipids & Porphyrins

1. Fate of dietary lipids and Apolipoproteins
2. Fatty acid biosynthesis, Desaturation of fatty acids
3. Beta oxidation, breakdown of odd chain fatty acids, energy yields
4. Regulation of β–oxidation, ω–oxidation & α–oxidation
5. Metabolism of phospholipids & Sphingolipids
6. Regulation and Biosynthesis of cholesterol and other steroids
7. Fate of acetyl CoA, formation of ketone bodies and ketosis
8. Biosynthesis of Prostaglandins, Prostacyclins,Thromboxanes, Leukotrienes
9. Role of HDL, LDL, and Very-low-density lipoprotein (VLDL) and cholesterol levels in body
10. Catabolism of Porphyrins, Genetic defects in lipid metabolism: Medium chain acyl coenzymeA dehydrogenase deficiency (MCAD), Long-chain 3-hydroxyacyl-CoA dehydrogenase (LCHAD) deficiency, Familial hyper cholesterolemia, Lipoproteinemias. Sphingolipidosis.

Paper-II BI102T: Chemistry Metabolism of Carbohydrates, Nucleic Acids and Vitamins (Core, 4 Credits; 100 Marks)

Unit–I: Chemistry of Carbohydrates

1 Classification, monosaccharides (aldoses & ketoses)
2 Configuration and conformation of monosaccharides (pyranose & furanose, chair & boat)
3 Reducing and optical properties of sugars
4 Stability of glycosidic bond, disaccharides, oligosaccharides
5 Structural polysaccharides-cellulose, hemicellulose, pectin, lignin, chitin, chitosan
6 Storage polysaccharides: Starch, Glycogen, Inulin
7 Steric factors in polysaccharides folding, sugar code and lectin
8 Glycosamino glycans, Mucopolysaccharides, Hyaluronic acid
9 Chondriotin sulfate, keratin sulfate, dermatan sulfate
10 Bacterial cell wall proteoglycans and peptidoglycans

Unit–II: Metabolism of Carbohydrates

1 Reactions and energy balance in Glycolysis
2 Reactions and energy balance in Gluconeogenesis
3 Reactions and energy balance in TCA cycle
4 Pentose phosphate, Pasteur and Crabtree effect
5 Anaplerotic reactions
6 Glyoxylate cycle
7 Glucuronic acid cycle
8 Glycogen metabolism
9 Photosynthetic reactions for biosynthesis of Glucose
10 C3and C4cycle in plants

Unit–III: Chemistry and Metabolism of Nucleic Acids

1 Purines, pyrimidines, nucleosides, nucleotides, unusual bases
2 Structure of DNA–Watson Crick Model, A-and Z-forms
3 Super coiling of DNA–negative and positive, linking number
4 Structure of RNA, tRNA, rRNA, siRNA/miRNA
5 Properties of NA–denaturation and renaturation
6 Tm (factors affecting T_m) and $C_o t$ curves
7 Hetero duplex mapping–D loops and R loops
8 Biosynthesis of purines and pyrimidines
9 Degradation of purines and pyrimidines
10 Regulation: *denovo* and salvage pathways, nucleotide analogs, Genetic defects in nucleotide Metabolism: Gout

Unit–IV: Chemistry and Metabolism of Vitamins

1 Discovery of vitamins, classification, RDA
2 Vitamin A–source, biological role and deficiency
3 Vitamin B1–Thiamine–source, biological role and deficiency
4 Vitamin B2–Riboflavin–source, biological role and deficiency
5 Vitamin B3–Niacin and B5–Pantothenicacid–sources, biological role and deficiency
6 Vitamin B6–Pyridoxamine and B7–Biotin–source,biological role and deficiency
7 Vitamin B9–Folic acid and B12–Cobalamine–source, biological role and deficiency
8 Vitamin C–Ascorbic acid–source, biological role and deficiency
9 Vitamin D-Calciferol–source, biological role and deficiency
10 Vitamin E, Vitamin K–source, biological role and deficiency

Paper -III BI103T: Bioanalytical Techniques (Core, 4 Credits; 100 Marks)

Unit–I: Spectroscopy

1 Beer Lambert's Law, Molar extinction coefficient, Absorption maximum
2 UV-Vis Spectroscopy, Colorimetry–principle, instrumentation, applications
3 Fluorescence Spectroscopy–principle, instrumentation, applications
4 Atomic Absorption Spectrometry–principle, instrumentation, applications
5 NMR–principle, instrumentation, applications
6 ESR–principle, instrumentation, applications
7 CD–principle, instrumentation, applications
8 ORD–principle, instrumentation, applications
9 Mass spectroscopy -principle, instrumentation, applications
10 X-ray crystallography

Unit–II: Chromatography

1 Partitioning and countercurrent distribution
2 PC–principle, instrumentation, applications
3 TLC–principle, instrumentation, applications
4 GC–principle, instrumentation, applications
5 Ion exchange chromatography –principle, instrumentation, applications
6 Gel filtration (Gel exclusion chromatography)–principle, applications
7 Affinity chromatography–principle instrumentation, application; immune precipitation
8 HPLC and RP-HPLC–principle, instrumentation, applications
9 FPLC,LC–principle, instrumentation, applications
10 Peptide mapping and N-terminal sequencing of proteins

Unit–III: Centrifugation and Electrophoresis

1 Centrifugation -RCF and types of rotors
2 Ultracentrifugation–principle, instrumentation, applications
3 CsCl density gradient and sucrose gradient centrifugation–principle & applications
4 Electrophoresis–moving boundary and zonal electrophoresis
5 Native and SDS PAGE, IEF and 2D PAGE
6 Agarose Gel Electrophoresis , PFGE
7 Zymography, PAGE for DNA sequencing
8 DNase-I hypersensitivity mapping
9 DNA-Foot-printing and Chromatin IP method
10 Denaturing gels for RNA, Southern and Northern Blots

Unit–IV: Tracer Techniques

1 Stable and radioactive isotopes, Radioactivity theory, half life and emission spectra of half life of biologically useful isotopes- ^{2}H, ^{3}H, ^{14}C, ^{18}O, ^{32}P, ^{35}S, ^{125}I
2 Isotopes used for labeling of proteins (^{3}H, ^{14}C, ^{35}S, ^{125}I) and nucleic acids (^{3}H, ^{32}P)
3 Detection of radioactivity by Scintillation counting
4 Autoradiography, Fluorography, Phosphor-imaging, applications
5 GM counter, gamma counter
6 Radiation hazards and safe disposal of radioactivity waste; Luxometry and chemiluminescence as an alternative to radioactivity
7 Isotope dilution method–pulse chase
8 Historic examples- ^{14}C and ^{18}O to study Photosynthesis
9 Historic examples- ^{31}P and ^{32}S to study viral replication (Hershey-Chase experiment)
10 Historic examples- ^{14}N and ^{15}N in DNA replication (Meselson and Stahl experiment)

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Paper-IV: BI104T: Bioenergetics and Cell Biology (Core, 4 Credits; 100 Marks)

Unit–I: Bioenergetics

1 Elements of importance in Biochemistry (H, C, N, O, P, S), types and energy of bonds and interactions (ionic, covalent, coordinate, H-bonds, vander waals, hydrophobic interactions)
2 Laws of thermodynamics, Gibbs free energy, relevance of entropy and Enthalpy in biological systems and reactions;
First and second-order reactions
3 Log and ln scales in biological processes (exponential growth curves, radio active decay)
4 Biological oxidation, high energy compounds
5 High energy bonds, redox and phosphate potential
6 Structure of membrane, forces stabilizing membranes
7 Formation of ion gradients across a membrane (proton gradients in organelles), role of transporters and channels
8 ETC in mitochondria and chloroplasts, uncouplers and inhibitors of energy transfer
9 Polarization of cell, resting potential, action potential, propagation of impulse
10 Biological fluorescence (GFP and derivatives), Bioluminescence

Unit–II: Structure of Prokaryotic cells

1 Classification of prokaryotes (systems of classification)
2 Ultrastructure of Eubacteria, Cyanobacteria, Mycoplasma
3 Motility of bacteria, bacterial films, isolation of bacteria from natural sources
4 Sterilization of materials (autoclaving, dry heat, filtration, chemical disinfection, irradiation) and commonly-used media (minimal, enriched, selective) for bacterial growth
5 Staining methods for bacteria; maintenance, and preservation of bacterial cultures
6 Growth curve, Doubling time, Factors affecting growth–pH, Temperature, oxygen, agitation
7 Batch and continuous growth of bacteria, chemostat, synchronized cultures
8 Industrial (large-scale) growth of bacteria, fermenter design
9 Bacteria of industrial importance, development of commercially valuable strains
10 Discovery of antibiotics, mode of action of various classes of antibiotics, antibiotic resistance

Unit-III: Structure of Eukaryotic cells

1 Ultra-structure of animal cells
2 Ultra-structure of plant cells
3 Composition of cytoskeleton-microfilaments, microtubules, intermediate filaments
4 Nuclear skeleton-lamina, scaffold
5 Vesicle trafficking (endocytosis, exocytosis), role of Rabs and Rab GTPases
6 Structure of chromatin and chromosomes (centromere, telomere, kinetochore)
7 Mitosis, meiosis, and interaction of chromatin with cytoskeleton (attachment of spindle fibers).
8 Formation and structure of special chromosomes (polytene, lampbrush)
9 Cell cycle
10 Apoptosis

Unit–IV: Methods of Cell Study

1 Simple and Compound Microscope.
2 Phase contrast, dark field and polarization microscopy.
3 Electron microscopy, SEM, TEM; freeze fracture.
4 Fluorescence and Confocal microscopy; imaging live cells.
5 FRET and FRAP.
6 Atomic force microscopy.
7 Flow Cytometry and Fluorescence Activated Cell Sorting (FACS).
8 Plant tissue culture.
9 Animal and insect tissue culture.
10 Methods of cell disruption and fractionation, Isolation of organelles.

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Semester-I: Practicals (3 Credits; 75 Marks)

Paper-V: BI105P: Analysis of Biomolecules and Biochemical Preparations	Paper-VI: BI106P: Bioanalytical Techniques
1. Lab safety, GLP, preparation of standard solutions 2. Preparation of buffers, use of balance and pH meter 3. Qualitative analysis of Amino acids 4. Qualitative analysis of Carbohydrates 5. Qualitative analysis of Lipids 6. Determination of pKa and pI of an amino acid 7. Estimation of amino acids by Ninhydrin method 8. Quantification of Glycine by Formal titration 9. Iodine number of oil 10. Peroxide value/Acid value of fats 11. Estimation of Protein by Biuret method/ Lowry method 12. Purification of casein from milk, calculate yield 13. Isolation of Starch from potato 14. Isolation of Glycogen from liver 15. Isolation of Lecithin and Cholesterol from Egg yolk	1 Absorption spectrum of Tyrosine 2 Estimation of inorganic phosphate by Fiske-Subbarow method 3 Estimation of DNA by DPA Method 4 Estimation of RNA by Orcinol Method 5 Estimation of Fructose by Roe's method 6 Titration of calcium in milk 7 Titration of vitamin C 8 Estimation of total sugars by phenol sulfuric acid method 9 Estimation of reducing sugars DNS method 10 Separation of purines and pyrimidines by Paper Chromatography 11 1-D & 2-D PC of amino acids 12 PC of plant pigments 13. TLC of plant pigments/ lipids 14. Desalting proteins by dialysis 15. Gel filtration (size exclusion) chromatography

Project ideas:

1 Compare pigments in different plant parts, different flowers, plants and algae
2 Compare unsaturation of various oils and fats
3 Determine sugar /vitamin C content in various fruits and soft drinks, calcium content in various milk brands

References:

1. An introduction to practical biochemistry. By: David T Plummer. Publisher Tata McGraw- Hill
2. Biochemical Calculations–Segel, I.H.John Wiley& sons
3. Experimental Biochemistry: A Student companion- Sashidhar Rao, B and Deshpande, V. IK International (P) Ltd
4. Experiments and Techniques in Biochemistry: by Sheel Sharma, Galgotia publications.

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Semester II

Paper-I: BI 201T: Enzymology (Core, 4 Credits; 100 Marks)

Unit–I: Enzymes, Coenzymes and catalysis

1 Thermodynamics of catalysis, Energy of activation, Relation of ΔG and K_{eq}
2 Coupled reactions (endergonic and exergonic) in biochemical pathways
3 Methods to isolate and purify enzymes, Assays, Activity Units, Specific activity
4 Nomenclature and classification of enzymes: EC
5 Metal cofactors, and co-enzyme requirements
6 Vitamin cofactors:TPP, FMN/FAD, NAD/NADP, Pantothenic acid
7 Vitamin cofactors: PLP, Biotin, Folate, Cobalamine, Phylloquinone
8 Factors affecting catalysis (pH, temperature, pressure, enzyme and substrate concentrations)
9 Chemicals to identify active site residues: Arg, Cys, Lys, His
10 Site-directed mutagenesis to identify active site residues: Triose Phosphate Isomerase

Unit–II: Enzyme Kinetics

1. Single substrate assumptions, Briggs-Haldane equation.
2. Steady state, Michaelis-Menten kinetics (derive equation and transformations)
3. Transformation of Michaelis-Menten equation.
4 Bi substrate reactions: ordered, random, sequential, Ping-Pong
5 Distinction between ordered and random addition of substrates and products release.
6 Inhibitors (competitive, uncompetitive, noncompetitive, suicide), effect on kinetic constants
7 Enzyme inhibitors as drugs: RT and Protease inhibitors as anti-HIV drugs
8 Cooperativity in binding (oxygen binding to hemoglobin)
9 Multiple sites; Cooperativity: MWC model, KNF model
10 Slow transition and Hysteretic behavior in enzymes

Unit–III: Catalytic Mechanisms

1 Types of catalysis: acid-base, transition state, covalent intermediates
2 Reversible and irreversible activation of enzymes (pro-enzymes, phosphorylation)
3 Enzymes activation by ligand binding and dimerization (protein tyrosine kinase receptors)
4 Catalytic mechanism of RNase
5 Catalytic mechanism of Chymotrypsin, Trypsin
6 Catalytic mechanism of Lysozyme
7 Catalytic mechanism of Carboxy peptidase, Subtilisin
8 Allosteric regulation of Aspartate Transcarbamoylase
9 Regulation of Glutamine Synthetase
10 Multi-enzyme Complex: Fatty acid synthase

Unit–IV: Enzymes in Physiology and Biotechnology

1 Regulatory enzymes in carbohydrate metabolism (Glycolysis, TCA cycle)
2 Regulatory enzymes in nucleotide metabolism
3 Enzyme cascades (blood clotting, complement activation)
4 Enzyme cascades (cell division and Apoptosis)
5 Convergent and divergent evolution of enzymes
6 Reporter enzymes for gene expression (β-gal, β -glucuronidases, CAT);
Restriction enzymes and ligases in recombinant DNA technology
7 Enzymes in dairy (Rennin, lipases, lactases), brewing (amylases, proteases, glucanases),
Foodprocessingtechnology(invertase, pectinases, papain)
8 Enzymes in detergent (lipases, cellulases, proteases), paper (cellulases) and tanning
9 Enzymes in bioremediation, biofuel industry (cellulases)
10 Enzyme engineering: Catalytic RNA and antibodies; Designing High-Through put enzyme assays

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Paper-II: BI202T: Molecular Biology (Core, 4 Credits; 100 Marks)

Unit–I: DNA Replication

1 Models of Replication–random, conservative, semi-conservative
2 Prokaryotic and Eukaryotic DNA polymerases, Helicases, Ligases, Topoisomerases
3 Initiation–primosome, ori-sequences, accessory proteins
4 Elongation–replisome, leading and lagging strands, Okazaki fragments
5 Termination, Inhibitors of replication
6 Replication of circular chromosomes by theta model-φX174, *E.coli*
7 Replication of circular chromosomes by rolling circle (lambda phage) and Strand displacement model (mt-DNA)
8 Replication of linear chromosomes, telomeres, telomerase
9 Amplification–Polytene and double minute chromosomes
10 *Invitro* replication (PCR)

Unit–II: DNA Repair

1 Types of damage–oxidation, deamination, alkylation, adducts, breaks
2 Direct repair–MGMT, photo-reactivation, AlkB
3 Base Excision Repair (Short and Long Patch)
4 Nucleotide Excision Repair
5 Mismatch Repair
6 Repair of DSBs by NHEJ and Homologous recombination
7 Holliday junctions and repair of collapsed forks
8 SOS and bypass repair
9 Diseases due to defects in DNA repair
10 Roles of ATM, BRCA in DNA repair

Unit–III: Transcription and Translation

1. Prokaryotic and Eukaryotic RNA polymerases
2 Initiation–prokaryotic and eukaryotic promoter sequences
3 Elongation, Termination–rho dependent and independent
4 Post-transcriptional modifications-capping, PolyA addition
5 Splicing, RNA editing; Inhibitors of transcription
6 Structure of ribosome, nature of genetic code
7 Initiation of translation (role of cap, IRES, IFs)
8 Elongation of translation (role of EFs)
9 Termination of translation (role of RFs)
10 Inhibitors of protein synthesis

Unit–IV: Protein Sorting/Targeting and Degradation

1 Post translational modifications of proteins, role in targeting (isoprenylation)
2 Signal peptide (ERLS), role of SRP in translation of secreted proteins
3 NLS, Mitochondrial & chloroplast LS
4 Chaperones, HSPs in protein folding
5 Lysosomal pathways (endocytosis, crinophagy macroautophagy, Microautophagy, direct translocation from cytosol)
6 Lysosomal storage diseases
7. Ubiquitin-proteasome pathway, N-end rule
8. Immuno-proteasomes
9 PEST sequences and proteolysis
10 Misfolded proteins in Neurodegenerative diseases

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Paper-III: BI 203T: Biochemical Genetics and Model Organisms (Core, 4 Credits; 100 Marks)

Unit–I: Mendelian Genetics

1 Mendel's Laws, Importance of meiosis in Heredity
2 Non-Mendelian Inheritance–Maternal effect, Maternal influence, Cytoplasmic inheritance
3 Gene interactions-Epistasis, Expressivity, Penetrance
4 Sex-linked, sex-limited, and sex-influenced genes; Polygenic inheritance and polyploidy
5 Mutations (spontaneous/induced,somatic/germinal,forward/reverse,transition/transversions)
6 Mutations (Silent, mis-sense, non-sense,and frame shift mutations, conditional, leaky)
7 Detection, selection & isolation of microbial mutants, Estimation of mutation rates
8 Reversion and suppression of mutations
9 Mutagens–physical, chemical
10 Transposon mutagenesis, site-directed mutagenesis

Unit–II:Linkage and Mapping

1 Discovery of linkage, Morgan's experiments
2 Cytological proof of crossing over
3 2-and 3-point crosses
4 Recombination, Interference
5 Tetrad analysis
6 Mapping human genes by pedigree analysis; Fundamentals of population genetics (HWLaw)
7 Pedigrees of AR, AD, XR and XD inherited traits
8 Mobile genetic elements – Zea Ac, Ds and Spm elements
9 *Drosophila copia*,Yeast Ty elements
10 Using recombination to make knockout cells/organisms

Unit–III: Bacterial Genetics

1 Discovery of conjugation
2 Mapping bacterial genes by conjugation
3 Discovery of transformation
4 Mapping bacterial genes by transformation
5 Discovery of transduction
6 Mapping Bacterial genes by transduction
7 Discovery of transposition
8 Structure of transposons, replicative and conservative transposition, use as mutagens
9 Mapping phage genes–Fine structure of rII locus: Complementation analysis
10 Fine structure of rII locus: Deletion mapping

Unit–IV: Model Organisms

1 *Dictyostelium* to study cell–cell communication and differentiation.
2 *Saccharomyces* to study homologous recombination in mating type switch; site of formation of buds
3 *Neurospora* to study one gene–one enzyme hypothesis
4 *Drosophila* to study embryonic development (homeotic mutations)
5 *C. elegans* to study development and nervous system
6 *Danio* to study vertebrate development,GLO fish
7 *Xenopus* to study embryogenesis
8 *Mus* in bred and knockout strains, NOD and nude mice
9 *Zea* to demonstrate cytological proof of crossing over
10 *Arabidopsis* to study flower development

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Paper-IV: BI 204T: Endocrinology and Metabolic Disorders (Core, 4 Credits; 100 Marks)

Unit–I: Hormones and Endocrine glands

1 History of Endocrinology
2 Organization and classification of hormones, Endocrine systems and disorders
3 Basic mechanism of action of peptide hormones and receptors
4 Basic mechanism of action of steroid hormones and receptors
5 Chemistry, physiology of Hypothalamus - Pituitary axis
6 Chemistry, physiology of thyroid; Thyroid function tests, Thyroid scanning
7 Chemistry, physiology of parathyroid glands
8 Glycoprotein hormones (LSH, FSH, TH, hCG, POMC); Growth hormone family (GH, hCS, Prolactin)
9 Adrenal hormones
10 Gonads and Gonadal hormones

Unit–II: Endocrine regulation

1 Regulatory pathways (positive, negative, feed back loops), Regulation of biosynthesis of steroid hormones by peptide hormones (LH, FSH, ACTH)
2 Endocrine regulation of growth; Endocrine regulation of stress
3 Endocrinology of Ca homeostasis; Endocrine regulation of renal function
4 Endocrinology of blood sugar, hunger, digestion and obesity
5 Endocrine regulation of cardio vascular system (Angiotensin, BNP, ET1)
6. Endocrinology of fertility (changes in menstruation, pregnancy and menopause/ andropause) Causes of female and male infertility;
7 Gametogenesis and fertilization (natural and assisted (*in vitro*)), Implantation and placenta; Endocrinology of Pregnancy and parturition; Methods of Birth control
8 Placenta as source of stem cells, cord banking
9. Medical uses of steroid hormones (contraception, hydrocortisone, anabolic steroids);
10 Erythropoietin, Adipo-cytokines, Orexins, HRT

Unit-III: Disorders of Amino Acid and Carbohydrate Metabolism

1 Hyper phenylalaninemia
2 Disorders of proline and hydroxyproline metabolism
3 Alkaptonuria
4 Disorders of lysine metabolism
5. Disorders of tyrosine metabolism
6. Hemoglobinopathies;Thalassemia
7. Disorders of glycogen storage
8 Disorders of fructose metabolism
9 Disorders of Galactose metabolism
10 Pentosuria, Diabetes

Unit–IV: Disorders of Lipids and Nucleic Acids Metabolism

1. Disorders of acid lipase deficiency
2. Farber's disease
3. Neimann Pick disease
4. Goucher's disease
5. Krabbe disease
6. Sulphatide-lipidosis disease
7. Fabry disease
8. Down's and Turner's syndrome
9. Hyperuricemia
10. Heriditary Xanthinurea and Lesch-Nyhan syndrome

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Semester II: Practicals (3 Credits; 75 Marks)

Paper-V: BI205P: Enzymology and Genetics	Paper-VI: BI206P: Molecular biology and Endocrinology
1 Assay of urease (horse gram / any source) 2 Assay of catalase (liver / any source) 3 Assay of α amylase (saliva) 4 Assay of β amylase (sweet potato) 5 Effect of enzyme concentration on enzyme activity (salivary amylase) 6 Effect of Time course on enzyme activity (salivary amylase) 7 Effect of pH on enzyme activity 8 Effect of temperature on enzyme activity 9 Effect of Substrate concentration, determine K_m and V_{max} 10. Monohybrid ratio 11. Dihybrid ratio 12. Linkage analysis 13. Pedigree analysis 14. Pedigree mapping 15. Tetrad analysis	1. Isolate DNA (onion/thymus/other source), 2. Absorption spectrum to assess purity (A260/A280 ratio) of DNA 3. A260/A280 ratio of RNA to assess its purity 4. Determine T_m of DNA 5. Prepare RNA (yeast/other source) 6. Agarose Gel Electrophoresis for RNA/ DNA 7. Absorption spectrum, Molar Extinction Coefficient of purine/pyrimidine 8. Estimation of FSH 9. Estimation of LH 10. Estimation of T3 11. Estimation of T4 12. Estimation of TSH 13. Pregnancy Test (strip method) 14. Determine blood glucose 15. Determine urinary glucose

Project ideas:

1 Compare abundance of an enzyme in various sources
8 Compare sensitivity and/or specificity of different assays for the same enzyme
9 Find the effect of some treatment (drug) on your model organism
4 Screen natural sources for biodiversity (bacteria, phage, algae, antibiotic-resistant bacteria)

References:

1.Enzyme assays-A Practical Approach,Eisenthal,R and Dawson, MJ, IRL press
2.Practical Biochemistry-Rameshwar.A, Kalyani Publisher
3.Principles of Genetics by Eldon John Gardner, Michael J.Simmons, D.Peter Snustad; John Wiley
4.Modern Genetic Analysis Anthony JF Griffiths,William M Gelbart, Jeffrey H Miller, and Richard C Lewontin .Pub.W.H.Freeman;
5.Statistics:Basic Concepts and Methodology for the Health Sciences Daniel WW, PubWiley India
6.Lehninger Principles of Biochemistry, David L.Nelson, Michael M.Cox Publisher:W.H.Freeman.

Semester-III

Paper-I: BI 301T: Gene Regulation and Genetic Engineering (Core, 4 Credits; 100 Marks)

Unit – I: Gene Regulation in Prokaryotes and Viruses

1 Operon concept for gene regulation
2 Positive (+ve) & Negative (-ve) control – Lac operon
3 Attenuation – Trp operon
4 Dual promoters – Gal operon: Dual function of repressor – Ara operon
5 Phase variation in *Salmonella* flagellar protein synthesis
6 Sporulation gene expression in *Bacillus*
7 Riboswitch
8 Anti – termination in lambda phage
9 Lytic / lysogenic switch in lambda phage
10 Control of plasmid copy number

Unit – II: Gene Regulation in Eukaryotes

1 Chromatin structure in active and inactive regions – DNA Methylation.
2 Histone Acetylation, H2AX foci, Histone code
3 Transcriptional control: cell specific expression, promoters, enhancers, Transcription factors
4 Post-transcriptional control – Alternative splicing, RNA editing.
5 RNA transport and stabilty.
6 Translational feedback.
7 Gene silencing – inactivation of mammalian X chromosome.
8 Regulation by siRNA
9 Gal operon of yeast.
10 MAT locus and mating type switch in yeast, Antigenic variation in *Trypanosoma*

Unit – III: Genetic Engineering-I

1 Enzymes in rDNA technology: Restriction Endonucleases (discovery, properties)
2 Enzymes in rDNA technology: DNA polymerases, Nucleases
3 Enzymes in rDNA technology: Kinases, Phosphatases,Methylases and Ligases
4 Prokaryotic and Eukaryotic vectors (plasmids, cosmids, phagemid, BAC, YAC)
5 Shuttle vectors, Expression vectors
6 Construction of cDNA and genomic DNA libraries
7 Screening a library: +ve & -ve selection strategies; Preparation of probes
8 Creating KO cells, Cre – Lox systems.
9 Sequencing of DNA by Maxam-Gilbert and Sangar method.
10 Sequencing of DNA by Pyrosequencing.

Unit – IV: Genetic Engineering-II

1 Yeast 2 hybrid
2 Phage display
3 Reporter genes : GFP, β–Gal, Luciferase
4 Expression in heterologous systems – bacteria
5 Expression in heterologous system – yeast cells
6 Expression in heterologous system – insect cells
7 Expression in heterologous system – mammalian cells
8 Molecular markers – RFLP, AFLP
9 Random amplification of polymorphic DNA (RAPD), Short tandem repeat, single nucleotide polymorphism (SNP), Ribotyping
10 Synthetic Biology: Introduction and Applications (Plant meat, Kymriah - a treatment for leukemia, PROVEN-Nitrogen fertilizer)

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Paper-II: BI 302T: Immunology and Immunotechnology (Core, 4 Credits; 100 Marks)

Unit – I: Components of the Immune System

1 History of Immunology
2 Natural & Acquired immunity, Specific & non-specific immune response.
3 Cells & organs of immune system
4 Antigenic determinants, Epitopes, Haptens, Properties of strong antigens
5 Adjuvants – types, mode of action, and applications.
6 Classification, structure, and biological properties of Immunoglobulins
7 Isotypes, Allotype, Idiotypes.
8 Theories of antibody formation, Generation of antibody diversity
9 Genomic rearrangements of light and heavy – chain loci in B-cells
10 Genomic rearrangements in T-cell receptor, structure of CD3, CD4, CD8.

Unit – II: Events in Immune Response

1 Humoral & cell-mediated immune response
2 Activation of T cells & B cells
3 Kinetics and regulation of primary and secondary immune response
4 MHC proteins structure & functions
5 Antigen processing & presentation
6 Transplantation immunology; Graft Versus Host Disease
7 Complement fixation: pathways and biological consequences
8 Discovery and action of Interferons
9 Cytokines; Inflammation; Role in obesity, cancer
10 Tumor immunology

Unit – III: Immune Disorders

1 Hypersensitivity; Coombs classification
2 Type I-V hypersensitivity
3 Tests for diagnosis of hypersensitivity (Coombs), Tuberculin test
4 Auto immune diseases; classification
5 Study of selected auto – immune disorders of types I – V
6 Immuno- deficiency disorders – primary and secondary deficiencies
7 Gene therapy for ADA deficiency
8 Immunology of AIDS
9 Immunosuppressive drugs/agents & their mechanism of action
10 Immune evasion by bacteria and viruses

Unit – IV: Immunotechnology

1 Production of polyclonal antibodies; Animals models for production of antibodies
2 Methods of antibody purification: Salt precipitation, Affinity chromatography
3 Antigen-antibody binding (Equilibrium dialysis, Surface Plasmon Resonance); Affinity, Avidity
4 Immunoprecipitation methods - gel diffusion (Ouchterlony; Mancini); Immune-electrophoresis (Rocket, counter-, 2-D)
5 Agglutination tests (Direct and indirect), Inhibition of Agglutination, Complement fixation test, Inhibition of complement fixation
6 ELISA, RIA Western Blots; use of antibody staining for FACS
7 Hybridoma technology – production of monoclonal antibodies; applications in research and immunotherapy; antibody engineering
8 History and types of Vaccines; Conventional vaccines - killed, attenuated, and subunit vaccines
9 Modern vaccines; peptide, DNA, recombinant / vector, and anti-idiotypic vaccines
10 Schedules of common vaccination, Benefits and adverse consequences of vaccination

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Paper-III: BI 303T: A- Clinical Biochemistry (optional, 3 Credits; 75 Marks)

Unit – I: Clinical Biochemistry-I

1 Free radical metabolism, ROS in disease
2 Neuro-endocrine regulation
3. Endocrine regulation of growth
4 Endocrine regulation of salt, electrolyte and water, Acid base balance and imbalance
5 Endocrine regulation of calcium & phosphate
6 Specimen collection. Automation and QA in clinical laboratories
7 Examination of Urine & Blood
8 Examination of Sputum & CSF
9 Pregnancy test, prenatal diagnosis & genetic counseling
10 Clinical importance of Enzymes and isoenzymes

Unit – II: Clinical Biochemistry-II

1 Physiological Interrelationship between cardiovascular, respiratory and renal systems
2 Normal values for different blood tests and clinical implications
3 Diagnosis of anemia, thalassemia
4 Hyper cholesterolemia, Atherosclerosis.
5 Diagnostic enzymes: Principles of diagnostic enzymology.
6 Clinical significance of aspartate aminotransferase, alanine aminotransferase, creatine kinase
7 Clinical significance of aldolase and lactate dehydrogenase
8 Enzyme tests in determination of myocardial infarction
9 Biochemical tests for the diagnosis of heart diseases- HDL/LDL cholesterol, SGOT, LDH, CK, C-reactive protein, cardiac troponins.
10 Diagnostic and therapeutic uses of radioisotopes

Unit – III: Gastrointestinal, Liver and Renal function tests

1. Fractional gastric analysis: Achylia gastrica, Stimulation tests, Tube less gastric analysis
2. Structure and functions of the Liver.
3. Liver diseases: Jaundice, Hepatitis, Cirrhosis, Fatty liver
4. Liver function tests: conjugated and total bilurubin in serum, albumin: globulin ratio, hippuric acid and bromsulphthalein tests.
5. Serum enzymes in liver diseases: SGPT, GGT and alkaline phosphatase.
6. Kidneys-structure of nephron, urine formation
7. Normal and abnormal constituents of urine.Normal values for different urine tests and clinical implications
8. Biological buffers.
9. Role of kidneys in maintaining acid-base and electrolyte balance in the body.
10. Renal function tests- creatinine and urea clearance tests, phenol red test.

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Paper-III: BI 303T: B- Nutrition (optional, 3 Credits; 75 Marks)

Unit – I: Nutrition

1 Balanced diet; Calorific values of foods and their determination by bomb calorimeter. Specific dynamic action of foods
2 Nutritional assessment by clinical testing; Anthropometric and Biochemical testing
3 BMR and RDA for infants, children, adults and expectant / nursing mothers; Food fortification; probiotics.
4 Organs of digestive system; Enzymes (amylases, proteases, lipases)
5 Hormones in digestion (stomach, pancreas; gastrin, secretin, CCK);
6 Role of bile acids; Absorption; Control of food intake (leptin, ghrelin, peptide YY)
7 Cholesterol, sodium and blood pressure
8 Food born diseases; Staphylococcal food poisoning, *Salmonella*, *Bacillus* and *E.coli* infections
9 Microbial toxins types; botulism; Food poisoning of fungal origin: Ergotism, Aflatoxin.
10 Principles of food preservation, Preservation by high and low temperature, Chemical preservatives, salt, sugar as preservatives; New trends in preservation

Unit – II: Dietetics

1 Protein factor in nutrition
2. Role of carbohydrates in diet
3. Role of lipids in the diet
4 Malnutrition (PEM, Marasmus, Kwashiorkor), Obesity (BMI and other metrics)
5 Eating disorders; Anorexia and bulimia; Obesity and starvation.
6 Diet and longevity, ageing.
7 Diet in pregnancy and lactation (first 1000 days)
8 Composition and nutritive value of common foodstuffs
9 Electrolyte content of fluid compartments, Functions of electrolyte, Sodium, Potassium and Chloride, Absorption, Transport and balance
10 Factors effecting electrolyte balance and hydrogen ion balance.

Unit – III: Macrominerals and Microminerals

1 Macrominerals
2 Calcium Distribution in the body digestion, Absorption, Utilization, Transport, Excretion, Balance, Dificiency, Toxicity, Sources, RDA
3 Regulation of calcium concentration, Calcium interaction with other nutrients.
4 Phosphorus Distribution, Concentration in the body, Digestion, Absorption, Utilization, Transport, Storage, Excretion, Sources, Calcium: Phosphorus ratio.
5 Disorders of mineral metabolism: Hypercalcaemia, hypocalcaemia, normocalcaemia, hypophosphataemia and hyperphosphataemia
6 Iron Distribution, Concentration in the body, Digestion, Absorption, Utilization, Transport, Storage, Excretion, Sources
7 RDA, interaction with other nutrients
8 Role of iron in prevention of anaemia.
9 Microminerals: Iodine, Fluoride, Mg, Cu, Zn, Se, Manganese, Chromium, Sources, distribution in the human body
10 Physiology, function, deficiency and toxicity of microminerals

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Paper-IV: BI 304T: A- Human Physiology and Xenobiotics (optional, 3 Credits, 75 Marks)

Unit – I: Neurophysiology

1 Types of neuronal cells – Neuroglia, microglia, astrocytes, oligodendrocytes, Schwann, satellite and epididymal cells
2 Nerves: regeneration of nerve fibers, generation of nerve impulse, all or none principle.
3 Mechanism of synaptic transmission, transmission of nerve impulse.
4 Types of neurotransmitters and their receptors, mode of signaling
5 Electrical synapse and giant neurons
6 Division of vertebrate nervous system: CNS, PNS, ANS, regions of the brain
7 Sensory organs – eye, ear, skin, tongue and nose
8 Vision: visual system, rhodopsin and classical GPCR mechanism, termination of visual signal
9 Cone cells, specialization in color vision, physiology of colour blindness
10 Similarity between vision, olfaction and gestation

Unit – II: Structure and Physiology of Muscle

1 Structure of various types of muscle: striated, cardiac, smooth, fast twitch, slow twitch
2 Mechanism of muscle contraction, regulation of contraction
3 Role of actin and myosin in non-muscle cells.
4 Cytochalasins and cytokinesis.
5 Muscle gene expression, regulation at transcriptional and posttranscriptional level.
6 Role of muscle proteins in cell locomotion
7 Neuro-muscular transmission
8 Electromyography, Sherrington starling Kymograph (recording drum)
9 Disorders of muscle (dystrophy, myopathy, myotonia, paralysis, Myasthenia gravis)
10 Detection and treatment of muscle disorders

Unit – III: Xenobiotics

1 Liver functions; pharmacopeia, drug deposition and mechanisms of drug detoxification
2 Cytochrome P450 enzymes: molecular biology, catalytic cycle, isozymes, inhibitors
3 Dose-response relationship, drug-receptor interactions
4 Pharmacodynamics; pharmacokinetics
5 Phase I reactions - modification
6 Phase II reactions - conjugation
7 Phase III reactions - elimination,
8 Environmental factors influencing drug metabolism
9 Effects and metabolism of model toxins: Aflatoxins, bacterial exotoxins (types I, II, and III)
10 Nutrient drug interactions

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BI 304T: B - NEUROBIOCHEMISTRY (optional, 3credits, 75 Marks)

UNIT-1:- NEUROMORPHOLOGY AND NEURO CELLULAR ANATOMY

Central Nervous System-general features neurons, cellular organization of neurons, dendrites and axons, neurotubules, neurofilaments, synapse, neuralgia, astrocytes, oligodendrocyte. Peripheral Nervous System-muscle nerve endings, sensory receptors and effectors endings, peripheral nerves, spinal and cranial nerves, plexuses ganglia, afferent pathways and sense organs. Spinal cord-Topographical anatomy, spinal nerves, spinal meninges, joint reflexes, grey and white matter of spinal cord. Formation, structure and biochemistry of myelin, chemistry of major brain lipids, development changes, lipid composition, biosynthesis and catabolism of major lipids, characteristics of brain lipids regional variations.

UNIT-II:- ROLE OF THE NERVOUS SYSTEM IN HOMEOSTASIS

Role of the nervous system in Homeostatic-Cellular organization of specific regions such as cerebellum, cerebral cortex, hippocampus, retina, evolution of the nervous system-a comparative aspect. Neurophysiology, neuronal membrane, excitability, ion channels and transport of ions. Nerve and Synapse Structures-structure function correlation at the synapse, Transmission across the synapse, membrane potential in the steady state, action potential generation and propagation. Pre-synaptic events at the neuromuscular junction-cholinergic and non-cholinergic synapses. Electrophysiology of channels-EEG patterns. Influence of age and development on cerebral energy metabolism, cerebral energy metabolism in pathological status, conclusive disorders, Coma.

UNIT-III:- NEUROCHEMISTRY

Neurotransmitters-Chemistry, Synthesis, Storage, release, receptors and function- acetyl choline, catecholamines, serotonin, histamine, glutamate, aspartate, GABA, glycine, neuropeptide, nitric oxide. Psychological and Biochemical theories of mental disorders-Chemistry of neuroleptics and anxiolytics, antidepressant, hallucinogenic agents, biochemical theories of mental disorders. Neurodegenerative disorders- Parkinson's, Alzheimer's diseases, amyotrophic lateral sclerosis, senile dementia. Neurological behavior-mechanism of sleep, wakefulness, self-stimulation.Nature, genetic and environmental factors affecting the development of CNS, Role of Psychiatrist and genetic counsellor.

Recommended Books: -

1. *Basic Neurochemistry, Molecular, Cellular and Medical aspects- George.J. Siegel, Bernard.W. Agra noff, R. Wayne Albers, Stephen.K. Fischer &Michael.D. Uhler.*
2. *From Neuron to Brain- John G. Nicholls, Robert Martin, Bruce G. Wallance& Paul A. Fuchs.*
3. *Ion channels, molecules in Action-David J. Aidley& Peter R. Stanfield.*
4. *Neurobiology Molecules, Cells and System-Gary G. Matthews*
5. *The Neurobiology of Memory, Concepts, Findings, Trends-YadinDudai*
6. *The Physiology of Excitable Cells-David j Aidley.*

Semester III: Practicals (3 Credits; 75 Marks)

Paper-V: BI 305P: Recombinant DNA and Immunotechnology

1 Restriction digestion of DNA
2 Preparation of competent cells
3 Transformation of competent cells
4 Gene cloning (demonstration)
5 Blue-white screening/α- complementation
6 Expression of heterologous protein in *E. coli*
7 Purification of IgG by Gel Filtration technique
8 Purification of IgG by Affinity Chromatography
9 SDS PAGE of Ig fractions
10 Agglutination: ABO and D Ag typing
11 Radial Immuno diffusion
12 Ochterlony double diffusion
13 Rocket Immunoelectrophoresis
14 Dot ELISA
15 Sandwich ELISA

References:

1. Molecular Cloning (Lab manual) by Maniatis T, Fritsch EF, Sambrook J, Volume –I, CSH
2. Lab Manual in Biochemistry, Immunology and Biotechnology – Arti Nigam and Archana Ayyagari –Tata McGraw-Hill New Delhi

Paper-VI: BI 306P: Nutrition and Clinical Biochemistry

1. Determination of total protein content in a food item
2. Determination of total carbohydrate content in a food item
3. Determination of lipid content in a food item
4. Qualitative analysis of abnormal constituents in urine
5. Determination of PCV and ESR
6. Differential count
7. Determination of osmotic fragility of RBC
8. Laboratory test to measure coagulation
9. Determination of urinary creatinine
10. Determination of blood haemoglobin
11. Determination of blood urea
12. Assay of serum Alkaline Phosphatase
13. Assay of serum ALT (SGPT)
14. Assay of serum AST (SGOT)
15. Assay of serum LDH

References:

1. Practical Clinical Biochemistry –Varley, H. CBS Publications
2. Practical Clinical Biochemistry-Methods and Interpretations – Ranjna Chawla- Jaypee
3. Manipal Manual of Clinical Biochemistry: For Medical Laboratory and MSc Students By S. Nayak, Shivnanda Nayak B, JAPEE Brother Medical Publications, New Delhi

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Semester – III, Interdisciplinary paper (C.B.C.S)
w.e.f. 2023-24 A.Y admitted batch

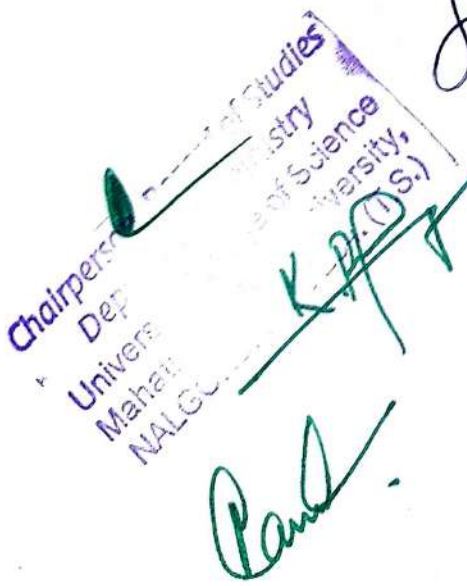
Subject: **Biomolecules & Basics in Nutrition**

Unit-I: Biomolecules

Introduction and scope of Biochemistry, importance of Biomolecules, outlines of classification and physiological importance of carbohydrates, proteins, lipids and nucleic acids, Vitamins.

Unit-II: Food and Nutrition

Introduction and importance of Nutrition, Nutritive values of food, classification of foods, Balanced diet and RDA, Neutraceuticals and functional foods, calorific values of foods, PEM/PCM, ; Food born diseases; food safety. Importance of microminerals, deficiency and toxicity of microminerals. Eating disorders: Anorexia and bulimia; Obesity and weight management, Diabetes; Role of iron in prevention of Anaemia. Electrolyte balance and hydrogen ion balance. GM food.



Paper-I: BI 401T: Biostatistics and Bioinformatics (Core, 4 Credits: 100 Marks)

Unit – I: Concepts in Biostatistics

1 Biostatistics fundamentals (sample, population, variable); Types of variables, Measurement and measurement scales
2 Measures of central tendency (mean, median, mode)
3 Measurement of dispersion (range, variance, standard distribution)
4 Study of bivariate data: correlation and regression; Regression to calculate concentration of DNA/protein, molecular weight of DNA/protein
5 Graphical methods to depict data (histograms, bar-plots, pie charts, line graphs)
6 Probability in biology, Laws of Probability
7 Bayesian probability
8 Normal distribution.
9 Binominal distribution.
10 Poisson distribution

Unit – II: Applications of Biostatistics

1 Design of experiments: factorial experiments
2 Student's t – test
3 F – test
4 Chi – square test; Contingency tests
5 CRD: Completely Randomized Design; 1-way ANOVA
6 RCBD: Randomized Complete Block Design; 2-way ANOVA
7 Non parametric tests: sign test
8 Wilcoxon signed rank test, Mann-Whitney test
9 Kruskal-Wallis test, and Friedman tests
10 Quality control in biochemistry

Unit – III: Genomics

1 Genomics and branches of genomics (Why study a genome?)
2. Basics of Bioinformatics: BLAST, FASTA, PAM and BLOSUM matrices
3. DNA sequence databases, Use of databases; data mining
4. Comparing DNA sequences, pair wise local and global alignment
5. Multiple sequence alignments (Phylogenetic trees, Clustal-W, COBALT)
6. HGP and Strategies for sequencing genomes (shotgun and hierarchical sequencing)
7.1st generation sequencing methods (Maxam and Gilbert Method; Sanger's method)
8.2nd and 3rd Generation DNA sequencing methods (Next Generation Sequencing)
9. Genetic and Physical maps of the genome. EST. STS
10. Epigenomics and metagenomics

Unit – IV: Transcriptomics and Proteomics

1 Relation of transcriptome to genome and proteome (Why study a transcriptome?)
2 Tools of transcriptomics: Northern blots, RNase protection assays, RT-PCR and Q-PCR
3 HT tools of transcriptomics: Microarrays for expression profiling, alternate sequencing
4 HT RNA sequencing: SAGE, MPSS, RNA-Seq, GIGA
5 Identifying expressed sequences by ChIP-seq, DNase-seq
6Transcriptome databases (ESTs, Transcriptome Shotgun Assembly, ArrayExpress)
7 Methods for sequencing proteins: Edman degradation
8 MS – MALDI. LC-MS, Tandem MS (MS-MS)
9 Micro-arrays for proteins, 2D gels and peptide maps
10 Proteins structure databases; Peptide sequence and MS profiles databases, Comparing protein sequences, alignment

Paper-II: 402T: Cell-Cell Communication and Signal Transduction (Core, 4Credits:100 Marks)

Unit – I: Extra Cellular Matrix (ECM) and Cell Surface

1. Molecules in the ECM in plant and animals.
2. Transport across cell membrane, Ficks Law.
3. Types of transport- simple, passive, facilitated.
4. Active transport, primary and secondary active transport system.
5. Ionophores, gated channels (Voltage and Ligand).
6. Cell communication and type of signaling molecules.
7. Types of receptors and their structure.
8. GPCR, inhibitory and stimulatory and type of down steam effectors and signal termination.
9. Monomeric G-proteins their role.
10. Drugs targeting signaling molecules

Unit – II: Cell Signaling

1. Cell division and differentiation.
2. Autocrine, paracrine & endocrine systems
3. Growth factors – EGF, PDGF
4. VEGF, IGF
5. Second messengers – Ca, calmodulin, inositol, NO, cAMP, cGMP
6. Receptors tyrosine kinases (Insulin signaling)
7. MAPK pathway, role in signaling.
8. Role of post-translational modification of proteins in signaling – phosphorylation.
9. Acylation, glycosylation, ADP ribosylation, myristoylation.
10. Signal cascades, Inhibitors of signal cascades.

Unit – III: Signal Transduction and Cancer

1. Discovery of oncogenes, proto-oncogenes
2. Modes of action of oncogenes – G proteins – Ras
3. Growth factors – Erb, Sis
4. Transcription factors – Fos, Jun, AP1, V-erbA
5. Discovery of tumor suppressor genes
6. RB and retinoblastoma, APC and colon cancer.
7. Modes of action of TS genes – p110, p16, p21, Phosphatase and tensin homolog (pTEN)
8. p53 and cancer risk
9. Selected examples – c-Myc and leukemia
10. BRCA and breast cancer

Unit – IV: Signal Transduction in Bacteria and Plants

1. Introduction of signaling components in bacteria
2. Chemotaxis
3. Protein kinases in bacteria
4. His-kinases: structure and role
5. Plant signaling system an over view
6. Stress signaling in plants (biotic)
7. Stress signaling in plants (abiotic)
8. Plants hormones and their mechanism of action
9. Signaling in yeast
10. STAT pathway in yeast

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Paper-II: 402T: Cell-Cell Communication and Signal Transduction (Core, 4Credits:100 Marks)

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6. RB and retinoblastoma, APC and colon cancer.
7. Modes of action of TS genes – p110, p16, p21, Phosphatase and tensin homolog (pTEN)
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9. Selected examples – c-Myc and leukemia
10. BRCA and breast cancer

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3. Protein kinases in bacteria
4. His-kinases: structure and role
5. Plant signaling system an over view
6. Stress signaling in plants (biotic)
7. Stress signaling in plants (abiotic)
8. Plants hormones and their mechanism of action
9. Signaling in yeast
10. STAT pathway in yeast

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Paper-III: BI 403T: A- Microbiology (optional, 3 Credits, 75 Marks)

Unit I: Bateriology

1. Classification of prokaryotes
2. Staining methods
3. Common culture methods (minimal, enriched, selective)
4. Structure of bacterial cell
5. Motility of bacteria, bacterial films
6. Sterilization methods (autoclaving, dry heat, filtration, chemical disinfectants, irradiation),
7. Maintenance and preservation of microbial cultures
8. Bacterial culture growth conditions, growthcurve, doubling time
9. Factors affecting growth –pH, temperature, oxygen and agitation
10. Chemostat, continuous and synchronous cultures

Unit II: Mycology

1. Classification: classification of Fungi (Ainsworth, 1973) upto sub-division with diagnostic characters and examples
2. Hyphal forms
3. Fungal spore forms and mode of liberation
4. Sexual reproduction and degeneration of sex
5. Homothallism and heterothallism, life cycle patterns
6. Anamorphic fungi and parasexuality
7. Life history of *synchytrium*
8. Life history of *Rhizopus, Ascobolus*
9. Life history of *Agaricus,* Micorrhiza types with salient features
10. Role in agriculture and forestry

Unit III: Virology

1. Discovery of bacteriophages; Structure and composition of bacteriophages; classification of animal viruses, Viriods and virusoids
2. Structure of naked and enveloped viruses
3. Genome diversity and host-virus interactions; permissive/non-permissive hosts; cytopathic effects
4. Isolation and purification by filtration, ultracentrifugation and affinity chromatography
5. Plaque assay and Pock assay, hemagglutination assay, transformation assay; Cultivation of viruses in animals and tissue culture
6. One step growth, single burst and eclipse experiments
7. Life cycle of model bacteriophages infecting *E.coli* – lambda phage (lytic and lysogenic)
8. Φx174, Qβ, M13, T4, T7; Life cycle of animal viruses – SV40
9. Adenovirus, Poliovirus; Retroviruses – RSV/HIV
10. Plant viruses – TMV, CaMV; Phages in therapy

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BI 403T: B –BIONANOTECHNOLOGY (optional, 3credits, 75 Marks)

UNIT-I: - NANOBIOLOGY AND BIOMATERIALS

Nano-definition, biosystems, biological networks, Bionanoparticles-nanocomposites, nanoparticles. Nanofibers-electrospinfibers, self-assemble fibers, conjugation, fabrication, advantages and issues. Biomaterials- Introduction, types of biomaterials, biodegradable polymers, biodegradation of solid polymers. Modes of erosion (surface & bulk). Molecular effects on hydrolytic breakdown, Microbes assisted synthesis of Nanoparticles. Biomedical sensors and Biosensors: Biosensors-definition and classification-potential based sensors; electrochemical sensors; acoustic/mechanical sensors; thermal and phase transition sensors in modern medicine- Biomembrane based sensors.

UNIT-II CHARACTERIZATION OF NANOSTRUCTURES

Techniques to construct nanostructures- scanning probe instruments, nanoscale lithography. Techniques to predict nanostructures- TEM, SEM, AFM. Characterization techniques- NMR, MALDI-TOF spectroscopy- UV-Vis, FT-IR and RAMAN, SERS, X-ray diffraction, ECSA, EDAX. Quantification of Nanoparticles by ICPOES & ICPMS.

UNIT-III: - APPLICATIONS OF NANOMATERIALS

Diagnostic imaging techniques (digital imaging; molecular imaging). Nanoengineered biosensors. Fiber Optic Nanosensors in medical care. Application of nano materials in medicine:-neuroscience, cancer therapy, cardiovascular medical devices; tissue regeneration (tissue engineering). Dendrimers as nanoparticulate drug carriers. Drug delivery systems-polymer therapeutics: polymer drug conjugates; polymeric micelles; liposomes. Mechanical testing; elasticity; toughness; effect of fabrication on strength. Nanoparticles for drug delivery (including solid lipid nanoparticles, synthetic, and biopolymeric nanoparticles)

Recommended Books:-

1. Molecular Design and Synthesis of Biomaterials Biological Engineering Division, MIT open course ware, 27th May 2005.
2. Biomaterials Sciences-An Introduction to materials in Medicine 2nd Edition, Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack. E. Lemons.
3. Nanotechnology: A Gentle Introduction to the Next Big Idea Mark Ratner and Daniel Ratner, Pearson Education Publishers, 2002.
4. Encyclopaedia of Nanoscience & Nanotechnology, H.S. Nalwa (E.D), American Scientific Publishers, California, 2004.
5. Nano biotechnology: concepts, applications and perspectives, Christof M. Niemayer, Chad A.Mirkin, Wiley VCH publishers 2004.
6. Bionanotechnology: Lessons from Nature, David S. Goodsell, Jhonwiley 2006.

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Paper-IV: BI 404T: A- Biotechnology (optional, 3 Credits, 75 Marks)

Unit – I: Microbial Biotechnology

1 Large scale cultivation of microbes; Fermenter design and control of growth
2 Downstream processing
3 Production of biomass, single cell protein
4 Production of low molecular weight primary and secondary metabolites
5 Microbial insecticides; tissue plasminogen activator; tags for protein purification
6 Production of enzymes for industry (high fructose corn syrup, cheese, food processing)
7 Microbial polysaccharides-Xanthan gum, Dextran, Pullulan, Mannan, Curdlan, Alginate
8 Microbial mining (mineral leaching)
9 Microbial production of interferon; PEGylated interferon
10 Microbial degradation of oil (bioremediation); Methods and applications of Immobilized cells and Immobilized enzymes

Unit – II: Plant Biotechnology

1 Plant cell culture: callus, protoplast fusion, differentiation into plantlets
2 Plant vectors, Ti plasmids
3 GM plants, GM foods
4. IPR and farmers' rights in GM plants
5 Anti sense RNA and DNA
6 Plantibodies
7 Case studies (genes involved, commercial value, problems) of StarLink corn, Bt cotton
8 Case studies of Zeneca tomato paste, FlavrSavr tomato
9 Case studies of Golden rice, Herbicide resistant plants
10 Virus resistant plants

Unit – III: Animal Biotechnology

1 Development, maintenance and growth of animal cell lines
2 Cloning of mammalian species (Dolly); Production of viral vaccines
3 Production high value therapeutics, interferon
4 Plaminogen activator, urokinase
5 Monoclonal antibodies, chimeric antibodies
6 Immunotoxins as therapeutic agents
7 Gene knockouts and transgenic animals
8 Human gene therapy
9 "Humanized" animals as organ farms
10 Large-scale and site-directed mutagenesis; Methods of drug design and delivery.

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BI 404T: B- Biochemical Pharmacology and Toxicology (optional, 3credits, 75 Marks)

Unit I: Basic Concepts in pharmacology and Toxicology

Pharmacopeia, drug deposition and mechanism of their detoxification, fate of foreign compounds in the body, physiochemical interactions. Drug conjugation reactions, Cytochrome p450 enzymes, Dose–response relationship, drug-receptor interaction. Environmental factors influencing drug metabolism, Pharmacodynamics, pharmacokinetics and pharmacogenetics. Definition, Classification of toxic agents. Desired and undesired effects. Various factors affecting toxicity: vehicles, formulation factors, biological half life, volume and concentration, dose, dosage forms, routes of administration/ entry, genetic status etc. Principles of selective toxicity: comparative morphology, comparative biochemistry, comparative cytology. Toxicity assessment: acute, subchronic, chronic exposure, determination of ED50 and LD50 values, tests for mutagenecity , carcinogenicity, genotoxicity, Ames test.

Unit II: General principles of Drug therapy and Drug resistance:

Mechanism of action and cellular resistance to Antibacterial Drugs. (a) inhibitors of bacterial cell wall synthesis (Penicillin, Cephalosporin, Carabapenam, vancomycin) Structure of bacterial cell wall; (b) Inhibitors of protein synthesis (tetracycline, streptomycin, erythromycin, chloramphenicol etc.). General principles of cancer chemotherapy; Mechanisms of action and cellular resistance to anticancer drugs (purine and pyrimidine analogs, antimitotic drugs, DNA intercalating agents, alkylating agents, methotrexate etc.).

Unit III: Toxicology of drugs

Selection of drug-resistance mutants in mammalian cells and their application for Genetic and Biochemical studies- studies with mutant resistant to Podophyllotoxin and Etoposide. Mechanism of action and cellular resistance to antiviral drugs and bacterial toxins, (cholera toxin, diphtheria toxin). Pharmacology and toxicology of drugs used in Autonomic nervous system (ANS), Central nervous system (CNS), Cardio-Vascular System (CVS) and Gastrointestinal (GIT). Autocoid pharmacology, Analgesics and anti-inflammatory agents. Hormone and hormone antagonists.

Suggested References :

1. Pharmacology and Toxicology- Kale S.R.,6th edition, NiraliPrakashan, 2003
2. Principles of Pharmacology– The Pathophysiologic Basic – By Golan David E., Lipincott, Williams and Wilkins publishers. 3. Casarette and Doull's Toxicology by Klaassen CD
3. Pharmacological Basis of Theraputics- By Goodman and Gilman, 10th edition.
4. Essentials of Pharmacotherapeutics-By F.S. Barar, S. Chand Publishers .
5. Principles of Pharmacology – By Paul L. Munson, AHoodder Arnold Publications.
6. Pharmacology and Pharmacotherapeutics- By R.S.Satoskar, Popular Prakashan.
7. Pharmacotherapy- A Pathophysiological Approach- By Joseph T. Dipiro, McGraw- Hill Medical ;5th& 6th edition.
8. Lewi's Pharmacology – By James Crossland, Churchil Livingston publisher.
9. Modern Pharmacology with Clinical Applications- By Craig, Charles R, Lippincott Williams & Wilkins; 6th edition.
10. Principles of Pharmacology- By H.L. Sharma, Paras Medical Publisher. Detoxification mechanisms by Williams RT
11. Selective Toxicity by Albert A. 12. Developmental Toxicology by Hood RD.

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Semester IV: Practicals (3 Credits; 75 Marks)

Paper-V: BI 405P: Bioinformatics and Biostatistics

1 OMIM database and human genetic disorders
2 Retrieve DNA sequence from database (NCBI)
3 Retrieve protein sequence from database (NCBI)
3. Retrieve protein structure from database (PDB)
4. KEGG database for pathways
5. Local, Global alignment of DNA
6. Local, Global alignment of protein
7. Multiple sequence alignments
8. Descriptive statistics (Mean, Median and Mode)
9. Descriptive statistics (Range, Variance and Standard Deviation)
10. Correlation and regression
11. Binomial and Poisson
12. Normal distribution
13. Z and T tests
14. F test
15. Chi-square test

References:

1. Bioinformatics (Sequence and Genome Analysis) Mount David W, Press CSH
2. Biostatistics by con and conum
3. Biostatistics –Arora & Malhan, Himalaya Publishing House

Paper-VI: BI 406P: Microbiology and Biotechnology

1. Different sterilization methods
2. Preparation of different media
3. Isolation of Bacteria
4. Cultivation of Bacteria
5. Purification of Bacteria
6. Grams staining of Bacteria
7. Biochemical identification of Bacteria
8. Production of any microbial enzyme
9. Production of alcohol by *saccharomyces cerevisiaceae*
10. Polymerase Chain Reaction
11. Isolation of plasmid DNA
12. Plant tissue culture: Callus induction
13. Immobilization of yeast cells
14. Enzyme activity of immobilized yeast cells
15. Enzyme activity of unimmobilized yeast cells

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References:

1. Methods In Biotechnology, edited by Hans-Peter Schmauder. Taylor & Francis
2. Practical Microbiology, by D.K.Maheshwari , S. Chand Publishing, 2002

Paper-VII: BI 407: Project