Subject: M.Sc. Biochemistry, Course Structure

Semester: I

S.No	Course No.	Course title	Credits	CBCS code
1	BC401	Intermediary Metabolism I (Carbohydrate and Lipid)	3	HC
2	BC402	Biophysical Chemistry	3	HC
3	BC403	Computer Applications in Biology Lab	3	HC
4	BC404	Biochemical Techniques - I	4	SC
5	BC405	Introductory Physiology	3	HC
6	PB401	Genetics	3	HC
7	PB402	Microbiology	3	HC
		Total	**22**	

Semester: II

S.No	Course No.	Course title	Credits	CBCS code
1	BC451	Enzymology	3	HC
2	BC452	Molecular Biology - I	3	HC
3	BC453	Structural Biology	3	HC
4	BC454	Intermediary Metabolism - II (Amino Acids and Nucleotides)	3	HC
5	BC455	Biochemical Techniques - II	5	SC
6	BC456	Cell Biology	3	HC
7	BC457	Biostatistics	2	HC
		Total	**22**	

Semester: III

S.No	Course No.	Course title	Credits	CBCS code
1	BC501	Basic Immunology	3	HC
2	BC502	Molecular Biology - II	3	HC
3	BC503	Bioenergetics and Biomembranes	3	HC
4	BC504	Biochemical Techniques - III	5	SC
5	BC520	Introduction to Bioinformatics **(Elective)**[a]	2	E
6	BC521	Endocrine Biochemistry **(Elective)** [a]	2	E
7	BC522	Proteomics **(Elective)** [a]	2	E
8	BC523	Developmental Biology **(Elective)** [a]	2	E
		[a]**Any two electives** **Total**	**18**	

Semester: IV

S.No	Course No.	Course title	Credits	CBCS code
1	BC551	Nutritional and Clinical Biochemistry	3	HC
2	BC552	Biochemical Techniques – IV	2	SC
3	BC553	Project	8	SBE
4	BC571	Protein Phosphorylation and Signal Transduction **(Elective)**	2	E
5	BC575	Principles in Cancer and Cancer Stem Cell Biology **(Elective)**	2	E
		Total	**17**	
CBCS CODES: HC: Hard core; SC: Soft core; E: Elective; SBE: Skill based elective				

M.Sc. Biochemistry
(Semester-wise Courses)
Semester I

COURSE NO: BC401: INTERMEDIARY METABOLISM I (CARBOHYDRATE & LIPID METABOLISM)- CORE COURSE- 3 CREDITS.

Introduction to Metabolism, Methods to study Intermediary Metabolism, Principles of Bioenergetics, Importance of ATP.

A. Carbohydrate Metabolism:

1. Brief account on the occurrence of carbohydrates, structure, properties and biological importance (monosaccharides, disaccharides and polysaccharides including mucopolysaccharides).
1. Breakdown of carbohydrates: digestion and absorption of carbohydrate, breakdown of glycogen, Starch and disaccharides.
2. Glycolysis: entry of other carbohydrates into the glycolytic sequences, alcoholic fermentation, regulation of glycolysis.
3. Citric acid cycle: establishment of the cyclic nature, individual reactions and enzymes of citric acid cycle. Amphibolic nature of the cycle.
4. Glyoxylate cycle. Control of citric acid cycle.
5. Pentose phosphate pathway of glucose oxidation. Importance of the pathway and its regulation.
6. Biosynthesis: biosynthesis of glucose from non-carbohydrate precursors (gluconeogenesis). Control of gluconeogenesis. Glycogen synthesis and its regulation, disaccharide biosynthesis.
7. Role of nucleoside diphosphate sugars in carbohydrate biosynthesis and in sugar inter conversions.
8. Glycoprotein biosynthesis

B. Lipid Metabolism:
1. Digestion and absorption of triglycerides, phospholipids, glycolipids and sterols.
2. Biosynthesis of saturated, unsaturated, hydoxy and branched chain fatty acids.
3. Oxidation of fatty acids and different pathways for such oxidation. Biosynthesis and degradation of phospholipids.
4. Glycolipids. Sterol biosynthesis and conversion of cholesterol to various other biologically important compounds.
5. Formation of prostaglandins, prostacyclins and thromboxanes from unsaturated fatty acids.
6. Regulation of the various synthetic and degradative processes mentioned above.

COURSE NO: BC 402: BIOPHYSICAL CHEMISTRY – CORE COURSE – 3 CREDITS

1. Interactions in Biological Systems: Intra and inter molecular forces electrostatic interactions and Hydrogen bonding interactions, van der Waals and Hydrophobic interactions, Disulphide bridges, Role of water and weak interactions.
2. Principle of biophysical chemistry- pH, buffer, pKa, equilibrium, titration curve of amino acids, and colligative properties. Oxidation and reduction phenomenon in biological systems, redox potential calculation.

3. Separation and characterization of macromolecules, detergent, electrophoresis and chromatography
4. Sedimentation- Ultracentrifugation, basic principle, sedimentation rate analysis, sedimentation velocity, sedimentation equilibrium and application.
5. Spectroscopy: basic principle of absorption and fluorescence spectroscopy and their application.
6. Radio-isotopic technique: measurement, detection and application in biology
7. Bio-thermodynamics: basics and application of thermodynamic in biology

COURSE NO: BC 403: COMPUTER APPLICATIONS IN BIOLOGY -Lab COURSE – 3 CREDITS.

1. Introduction to Bioinformatics and Computational Biology: History and major developments
2. Introduction to sequence, structure, pathways, and other Biological Databases and Computational Tools
3. Database development: The basics
4. Nucleic acid sequence analysis: Sequence alignment, substitution matrices, secondary structure elements, motifs
5. Protein sequence analysis: Sequence alignment, substitution matrices, secondary structure elements, motifs
6. Evolutionary analysis: Phylogenetic tree construction using Distance-based, Maximum parsimony and maximum likelihood methods; Tree reliability analyses; Tree visualization
7. Molecular modeling: RCSB PDB database, Protein tertiary structure prediction using homology modeling and threading, small molecules, force fields, energy minimization and molecular docking
8. Applications to biological problem solving

COURSE NO: BC 404: BIOCHEMICAL TECHNIQUES-I- CORE COURSE- LAB- 4 CREDITS

COMPONENT 1: Basic Methodology and Instrumentation.

1. Preparation of buffers (volatile & nonvolatile) pH measurement; pH indicators, accurate measurement of pH-Various common buffers used in biochemical research.
2. Colorimetry. Use of colorimeter, its limitations Description of colorimeters Filter; grating relation between O.D & Transmittance Beers law; absorbance curves of two dyes.
3. Colorimetric estimation of P and organic PO_4 (by digestion) Fiske & Subbarao method/Bartlett or other
4. Estimation of DNA by diphenylamine method.
5. Estimation of RNA by orcinol reaction
6. Spectrophotometry: UV and Visible Spectrophotometer. The absorption spectrum of P-nitrophenol U.V absorption of nucleic acids, amino acids and proteins.
7. Building a calibration curve of protein through Bradford method and applying errors.

COMPONENT 2: Isolation and characterization of Carbohydrates & Lipids
1. Isolation of glycogen from Liver/Muscle Total carbohydrate Estimation by Anthrone method.
2. Determination of reducing sugar in glycogen (by 3,5 dinitro salicylic acid)

3. Preparation of phosphatidyl choline from egg yolk-purification by chromatography and lipid phosphorus estimation.
4. Isolation of cholesterol from brain.
5. Paper chromatography: Separation of sugars (mono and disaccharides)
6. 2-dimensional paper chromatography, Amino acid
7.T.L.C separation of phospholipids (Extracts of E.coli, Liver and leaf identification by iodine and ninhydrin.

COMPONENT 3: Genetics:

1. Genetics Dry Lab: Problems
a. Mendelian analysis
b. Gene interactions
c. Chromosomal basis of inheritance
d. Linkage and crossing over
e. Tetrad analysis
f. Non-Mendelian Genetics (extra-nuclear inheritance)

2. Wet Laboratory
a. Radiation Sensitivity of yeast
b. UV mutagenesis
c. Mating, zygote selection sporulation and tetrad analysis
d. Yeast position effect assays/ chromosomal loss assays
e. Demonstration of Drosophila homeotic mutants/ polytene chromosome preparation
f. Mitosis from onion root tips

COURSE NO. BC405: INTRODUCTORY PHYSIOLOGY – CORE COURSE – 3 CREDITS

(Primarily with reference to human, a comparative account will be discussed wherever possible/applicable)

Digestive system - Functions of gastrointestinal tract and its associated glands; Mechanical and chemical digestion of food; Role of gastrointestinal hormones; Control and action of GI Tract secretions; Disorders of the digestive system.

Respiratory system - Comparison of respiration in different species, anatomical considerations like Skin, Gills, Lungs, Air sacs and voice apparatus, Air bladder and accessory breathing organs in fishes. Mechanisms of breathing. Histology of trachea and lung; Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen in the blood (oxygen-hemoglobin and myoglobin dissociation curve and its influencing factors), Carbon monoxide poisoning; Carbon dioxide transport in the blood; Regulation of acid-base balance; Control of respiration. transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.

Cardiovascular System: Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above. Blood and circulation - Composition; Blood corpuscles, plasma function, Haemopoiesis; Haemostasis; Coagulation of blood; blood volume, blood volume regulation, blood groups; Disorders of blood.

Excretory system - Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, Histology of kidney, ureter and bladder; Renal blood supply; Mechanism and regulation of urine formation; Regulation of acid-base balance; Renal failure and dialysis.

Nervous system - Neurons, action potential, Central & Autonomic Nervous System, Cranial nerves, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture. Sense organs-Vision, hearing and tactile response.

Muscles: Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, summation, tetanus and muscle dystrophies.

COURSE NO: PB401: GENETICS-CORE COURSE-3 CREDITS

1) Mendelian Genetics and analysis: Extension of Mendelian analysis
2) Chromosomal basis of Inheritance
3) Chromosome characteristics: Chromosome structure, Euchromatin and heterochromatin, Coding and Non-coding sequences, transposons
4) Genetic Recombination in Eukaryotes: Linkage and Crossing Over, Chromosome mapping, Tetrad analysis and Gene Conversion
5) Mutations and mutagenesis: Detection, Molecular basis and Applications
6) Chromosomal Changes: Number variation – Euploidy (auto and allopolyploidy), aneuploidy. Structural variations – Deficiences, duplications, Inversions, translocations
7) Interaction of Genotype and Environment: Twin studies, genetic environment, non-genetic environment, phenocopies, penetrance and expressivity
8) Gene expression regulation during differentiation and growth: Heterochromatization in human beings and other mammals, dosage compensation, mechanism, sex chromatin, position effect
9) Quantitative inheritance: Continuous traits – multigenic variability, dominance – additivity, norms of reaction
10) Non-Mendelian Inheritance: Plastid mutations – nature and mode of transmission; Mitochondrial traits – nature and mode of transmission; Applications
11) Population Genetics: Genotype and allelic frequencies, the Hardy-Weinberg equilibrium, non-random mating, consequences of homozygosity, factors affecting gene frequencies, heterosis, mutation – effect on allele frequencies, migration and genetic drift
12) Developmental Genetics: Model system *Drosophila*, Genetic screen, Pattern formation, Maternal effect, Homoetic transformations.

COURSE NO: PB402: MICROBIOLOGY-CORE COURSE-3 CREDITS

1) Beginnings of microbiology: Discovery, Evolution of microbiology as a discipline
2) Importance of microorganisms in environment and industry
3) Nutritional requirements of microorganisms: Nutritional types, Requirements,
4) Uptake of nutrients, Design and types of nutrient media
5) Diversity of microorganisms: Culture techniques, Overview of bacterial systematics
6) Microbial growth: Principles, Kinetics and Methods of measuring growth, Batch and continuous growth, Synchronous culture, Diauxic growth
7) Structure function relation in bacterial cell - Cell wall, cell membrane
8) Bacterial responses to chemical signaling

9) Overview of Plant-microbe interactions : Symbiotic nitrogen fixation, Mycorrhizae, Plant pathogens
10) Infection and disease – Host parasite relationship – Establishment of disease
11) Physical and chemical control of microorganisms
12) Chemotherapeutic agents and antibiotics
13) Foundations of virology - structure and replication, nomenclature and classification, detection, inhibition, viral vaccines, viroids, and prions

Semester II

COURSE NO: BC451: ENZYMOLOGY- CORE COURSE- 3 CREDITS

1. Enzyme nomenclature and classification: The naming and classification of enzymes
2. Enzyme isolation and purification: Origin of enzymes, Extraction of enzymes, Enzyme assay methods, Protein assay methods, Enzyme purification, Chromatographic methods.
3. Enzyme kinetics: Introduction to catalysis and kinetics, Kinetics of single-substrate enzyme-catalyzed reactions, Significance of kinetic constants, Experimental measurement of kinetic parameters. Enzyme inhibition (competitive, non-competitive, uncompetitive and mixed inhibition), Kinetics of multi-substrate enzyme-catalyzed reactions.
4. Enzyme specificity and regulation: Enzyme specificity, Zymogens, Isozymes, Allosteric regulation, Haemoglobin and Myoglobin, Feedback inhibition.
5. Mechanism of enzyme action: Mechanisms of catalysis, Investigation of active site structure, Mechanisms of reactions catalyzed by enzymes without cofactors, Metal activated enzymes and metalloenzymes, Coenzymes in enzyme catalyzed reactions.
6. Immobilized enzymes: Methods of immobilization, Properties and industrial applications of immobilized enzymes. .

COURSE NO: BC452: MOLECULAR BIOLOGY – I – CORE COURSE- 3-CREDITS

1. Discovery of DNA. Early experiments in molecular genetics. Historical events that lead to the conclusion of DNA is the genetic material. [3 hours]
2. Structure of DNA and RNA. Chemical and physical properties of nucleic acids (stability of nucleic acids, buoyant density, purity of DNA, effect of acids, alkali, on DNA, viscosity, spectroscopic and thermal properties of nucleic acids). [3 hours]
3. Genome Analysis and complexity, Cot analysis, organization of protein coding genes, gene duplication, discovery of repetitious DNA fractions. Lines, Sines and Alu sequences. [2 hours]
4. Chromosomes, Chromatin and the nucleosome. Chromosome sequence, genome size, density and diversity; duplication and segregation; building blocks of chromosomes or nucleosomes, higher order structure and regulation of chromatin structure. [2 hours]
5. DNA replication in prokaryotes and eukaryotes: origin of replication, replication fork, replisome. Enzymes in DNA synthesis, structure, function and mechanisms of action. Methods for studying DNA replication and determination of origin of replication. Chromosome segregation: random versus biased segregation. Topological problems during replication. DNA supercoiling and topoisomerases in eukaryotes and prokaryotes. Mechanisms of actions of topoisomerases. [6 hours]
6. Mutations: Replication errors in DNA, chemical mutagens, spontaneous versus induced mutation. Types of DNA damages. Transposons and mechanisms of transposition. [3 hours]
7. DNA repair: direct repair system, excision repair (NER and BER), Mismatch repair (MMR), double stranded DNA break repair (DSB): non-homologous end joining and homologous recombination. [4 hours]

8. Biochemistry of Recombination; types of homologous recombination: Gene conversion and mating type switching, Site-specific recombination, VD-J recombination, applications of homologous recombination. CRISPR-Cas system [3 hours]
9. Recombinant DNA technology: Restriction digestion; applications of DNA polymerases and PCR.; DNA modifying enzymes in cloning; DNA sequencing; Cloning vectors and hosts, gene libraries, Screening libraries. [6 hours]

COURSE NO: BC453: STRUCTURAL BIOLOGY- CORE COURSE-3 CREDITS

1. Defining the terms for nucleic acids: nomenclature and symbols, atomic numbering scheme, torsion angles and their ranges, definitions of torsional angles in nucleic acids, sugar pucker modes, pseudo rotation cycle syn/anti orientation about N-Glycosidic bond, orientation about the C9-C51 bond, helical parameters, hydrogen bonding between bases.
2. Structure and conformational properties of bases, furanose sugars and phosphate groups, geometry of bases, preferred sugar puckering modes, bond distances and angles in furanoses, syn/anti conformation and other conformation aspects of nucleotides.
3. RNA Structure: RNA double helices, RNA triple helices, Watson-Crick and Hoogsteen base pairing, mini double helices formed by ApU and GpU, turns and bands in UpAH
4. DNA structure: A-DNA, B-DNA, C-DNA conformation, DNA-RNA hybrids, Z-DNA formation.
5. Basic structural principles of proteins: Building blocks of proteins, Peptide bond, Ramachandran plot, Protein folding, Motifs of protein structure, Alpha domain structures, alpha and beta structures, anti parallel beta structures.
6. Techniques used for structural analysis of proteins and nucleic acids: Basic principles of NMR, ESR, SPR and Mass spectrometry, XRD, and CD/ORD and determination of structural parameters by these techniques and limitations and precautions.

COURSE NO: BC454: INTERMEDIARY METABOLISM II (AMINO ACID AND NUCLEOTIDE METABOLISM) - CORE COURSE – 3 CREDITS

Amino acid Metabolism:
1. Protein digestion and absorption. Amino acid degradation. Overview of amino acid degradation, transamination and the role of pyridoxal phosphate, oxidative deamination.
2. Pathways of degradation of different amino acids (fates of carbon atoms of degraded amino acids) via pyruvate, acetoacetyl CoA leading to acetyl CoA-Ketoglutarate pathway, succinate pathway, fumarate pathway, oxaloacetate pathway.
3. Formation of nitrogenous excretion products. The urea cycle linking of urea cycle to citric acid cycle. Regulation of Urea cycle enzymes.
4. Biosynthesis of amino acids: Biosynthesis of nonessential amino acids, glutamic acid, glutamine, praline, alanine, aspartic acid, asparagines, tyrosine, cysteine, serine and glycine, folic acid and its role in one carbon transfer.
5. Biosynthesis of essential amino acids: Methionine, threonine, lysine, branched chain amino acids (isoleucine, leucine and valine),arginine, histidine, aromatic amino acids (phenylalanine, tryptophan) enzymes and regulation of amino acid biosynthesis.
6. Precursor functions of amino acids
7. Brief account of biological nitrogen fixation

Nucleotide Metabolism:
1. Introduction: functions of nucleotides, antibiotics, sugar-nucleotide complexes, purine ribonucleotide metabolism: de novo purine ribonucleotide biosyntheses and its regulation, purine

ribonucleotide biosynthesis from purine bases and ribonucleosides (salvage pathway). Inter conversion of purine ribonucleotides, catabolism of purine nucleotides and bases.

2. Pyrimidine ribonucleotide metabolism: de novo biosynthesis of pyrimidine ribonucleotides and regulation, pyrimidine ribonucleotide biosynthesis from bases and ribonuclelosides (salvage pathway). Catabolism of pyrimidine bases.

3. Purine-pyrimidine-deoxyribonucleotide metabolism: deoxyribolucleoside metabolism, enzymatic reduction of ribonucleotides, thymidine metabolism regulation of deoxynucleotide metabolism. Biosynthesis of nucleotide coenzymes.

COURSE NO: BC 455: BIOCHEMICAL TECHNIQUES-II-CORE COURSE- LAB- 5 CREDITS

COMPONENT 1: Enzymology

1 Assay of alkaline phosphatase from E.coli using P-nitrophenyl phosphate as substrate.

2.Partial purification of alkaline phosphatase from E.Coli

3. Characterization of alkaline phosphatase.

a. Effect of pH
b. Effect of substrate concentration (Calculation of Km)
c. Effect of Temperature (Q 10)
d. Inhibition studies

4. Assay of yeast isocitrate dehydrogenase (an allosteric enzyme): Effect of substrate concentration.

5. Lysozyme purification from egg white.

COMPONENT 2: Molecular Biology – I

1. Isolation of yeast genomic DNA (or from any other organism)
2. Amplification of your favorite gene (YFG) by PCR
3. Isolation of plasmid DNA from E. coli
4. Restriction digestion of plasmid DNA for cloning/restriction mapping
5. Ligation of DNA insert into cloning vector
6. Transformation in bacteria
7. Knocking out of a non-essential yeast gene by homologous recombination.

COMPONENT 3: Protein technology:

1. Estimation of protein : (Biuret, Lowry & Bradford- to understand relative merits)
2. Identification of N-terminal (FDNB/DANSYL chloride method)
3. Purification of Concanavalin A from Jack bean affinity chromatography

Immobilization of Con A, and isolation of glycoproteins such as alpha-mannosidase using Con-A-Sepharose chromatography.

4. Glycosidases assay and partial purification by ion-exchange and hydrophobic chromatography.

5. Gel Filtration: G-25 separation of a large protein & small peptide elution with gradient solution.

6. Protein denaturation monitored by CD. Emission and excitation scan of a protein using fluorescence.

COURSE NO: BC 456: CELL BIOLOGY -CORE COURSE -3 CREDITS

1) Cell architecture: variety in size, shape and function (2 hrs)
2) Structure and function of subcellular organelles; intracellular trafficking; cytoskeleton and cell motility. (14hrs)
3) Brief introduction to regulation of cell cycle and check-points, meiotic cell division (10 hrs)

4) Chromosome segregation and spindle assembly; Nuclear envelope assembly and disassembly; mechanism of cytokinesis (6 hrs)
5) Organelle division and segregation (mitochondria, ER, Golgi, peroxisomes, lysosomes) (4 hrs)
6) Methods in cell biology: Microscopy, histochemistry (2 hrs)

COURSE NO: BC 457: BIOSTATISTICS -CORE COURSE -2 CREDITS

1) Why Biostatistics? Different types of Biological data generated using various high-throughput techniques and the need for analyses and interpretations.
2) Samples and Populations, Probability, Measures of central tendency and dispersal' Probability distributions (Binomial,Poisson and normal)' Sampling distribution
3) Difference between parametric and non-parametric statistics
4) Confidence Interval; Errors; Levels of significance: Null hypothesis, Alternative hypothesis, p-value, adjusted p-value; Regression and Correlation; T-test; Analysis of variance; X^2 test.

Semester III

COURSE NO: BC 501: BASIC IMMUNOLOGY -CORE COURSE -3 CREDITS

1. Immunity- innate and acquired, innate immune mechanisms, acute phase reactants, properties of acquired immunity, Toll-like receptors.
2. Immunogens and antigens – Properties, factors governing immunogenicity, haptens, epitopes-size and identification. Adjuvants-properties and mechanism of action.
3. Immunoglobulins - Structure, isotypes, allotypes and idiotypes. Functions of antibody in relation to structure.
4. Antigen-antibody interactions- affinity of antibody, avidity, bonus effect, classical precipitin reaction, antigen-binding site of antibody, forces involved in antigen-antibody complex formation.
5. Lymphoid tissues- Primary and secondary lymphoid organs, structure and cellular organization. Lymphocyte traffic
6. Cells involved in the immune response- T cells, B cells, CD antigens, neutrophils, eosinophils and natural killer cells.
7. Antigen Presentation- pathways of antigen processing and presentation of intracellular and extracellular antigens.
8. Antibody response-primary and secondary antibody response, antibody response to haptens, enumeration of antibody-forming cells, T-dependent and T-independent antigens.
9.Macrophage- role in immune response and activation.
10. Cell mediated immunity-helper, cytotoxic,suppressor T cells. *In Vivo* and *in Vitro* assays for assessment of cell mediated immunity.
11. Complement-classical and alternate pathways of activation. Regulation of complement activation and functions, complement disorders.
12. Antigen Receptors on T and B cells- structure and function. Generation of receptor diversity.
13. Development of immune system- T cell ontogeny in thymus, thymic hormones, B cell development.
14. Immunological tolerance- pathways of tolerance and mechanisms of tolerance in T and B cells. Autoimmune diseases
15.Immunological tests- Immunodiffusion, immunoelectrophoresis, immunofluorescence, radioimmunoassay and enzyme-linked immunosorbent assay.
16. Hypersensitivity reactions – Classification, Type I – IV reactions. Allergy.
17. Immunity to bacterial, viral and parasitic diseases.

COURSE NO: BC 502: MOLECULAR BIOLOGY –II - CORE COURSE- 3 CREDITS

1. Expression of Genome in pro and Eukaryotes: Regulatory sequences in DNA, Chemistry of RNA synthesis, RNA polymerases, different RNAs, Transcriptional factors and the mechanism of action. Genetic code. Post-translational modification and splicing, capping, polyadenylation. Processing of rRNA, tRNA precursors. [6 hours]
2. DNA binding motif in proteins: Zinc finger, Helix-turn-helix and leucine zipper etc. [2 hours]
3. Regulation of RNA synthesis in lambda phage, prokaryotes (lac, ara, trp and his operones, stringent, relaxed control), eukaryotes and in during development. [6 hours]
4. Epigenetic control of gene regulation. epigenetic marks: modification of DNA and histones. Methods for studying epigenetic modifications (ChIP, Chip-Seq, MNase mapping, FAIRE etc.). Interacting between distinct chromosomal loci: 3C, 4C and Hi-C techniques. [3 hours]
4. Exon shuffling, RNA editing and different RNAs and their functions (including siRNA, microRNa and dsRNA, long non-coding RNA), Riboswitch. [3 hours]
5. Translation, ribosome, initiation, elongation and termination steps in protein synthesis, regulation of factors and translation. [4 hours]
6. Secretory Protein biosynthesis, Covalent modifications of proteins (Glycosylation, iodination, methylation, oxidation, phosphorylation etc.) [3 hours]
7. DNAse hypersensitivity, Random and Site specific mutagenesis, DNA foot printing, finger printing, RFLP, RNA synthesis, polysomes, Protein synthesis in vitro. [3 hours].
8. Methods for studying RNA and transcriptome: northern hybridization; RT-PCR; microarray analysis; SAGE. [3 hours]
9. Studying protein-protein interaction: Yeast two hybrid systems, Co-immunoprecipitation; GST-pull down; FRET and SPR (surface plasmon resonance) [2 hours]

COURSE NO: BC 503: BIOENERGETICS AND BIOMEMBRANES-CORE COURSE- 3 CREDITS

Bioenergetics:

1. Scope of the subject and course: energy as understood by biochemist, energy transformations in living systems.
2. Structure and localization of enzymes in mitochondria, marker enzymes, redox reactions and reactions that generate reducing equivalents (NADH, NADPH and FADH2).
3. Constituents of electron transport chain: Pyridine and flavin linked enzymes, Iron sulfur proteins, Cytochromes **b, c_1, c, a**, and **a_3,** role of Coenzyme Q in electron transfer. Role of cytochrome c other than in electron transfer.
4. Electron Transport Chain: History, Structure, sites of action for various inhibitors on ETC, importance of redox potentials, calculation of free energy decrease for substrate oxidation, Studies with sub-mitochondrial particles.
5. Structure and function of individual complexes of electron transport chain. Complex I, II, III, IV and V.
6. Mechanism of action of various ionophores, uncouplers and inhibitors of phosphorylation. Electrochemical gradient for protons, Different states of respiration (state 1-6), acceptor control, effect of ionophores and inhibitors on acceptor control.
7. Mechanisms of oxidative phosphorylation: Chemical coupling hypothesis, conformational coupling hypothesis, binding change model and rotational hypothesis.
8. Chemiosmotic hypothesis: Characteristics of oxidative phosphorylation that support this hypothesis, mechanism of proton translocation, Q cycle and experimental evidence for this

hypothesis. Experimental evidences against the hypothesis. Delocalized versus localized proton coupling. Role of cardiolipin in energy transduction. Energy charge of the cell and its regulation.

9. Standard free energy change ($\Delta G^{0\prime}$) and its relationship to products to substrate ratio. Additive nature of $\Delta G^{0\prime}$, Calculations of free energy change (ΔG) of few common reactions.
10. Photosynthesis: Biological occurrence, various electron donors and acceptors, Photosynthetic pigments, Photosynthetic electron transport chain, and photophosphorylation.

Biomembranes:
1. Structure and organization of membranes.
2. Transport of NADH, ATP, ADP, Pi, fatty acids and various metabolites across mitochondrial inner membrane.
3. Structure and function of ion gated channels. Operation of these channels at neuromuscular junction.
4. Transport by **P** type, **V** type and **F** type ATPases. Other ABC family transporters. Amino acid transport and glucose transport by glucose transporters. Anion and cation symport and antiport systems.
5. Active transport in bacteria, Group translocation, lactose permease for lactose transport.

COURSE NO: BC 504: BIOCHEMICAL TECHNIQUES-III- CORE COURSE- LAB (5 CREDITS)

COMPONENT 1: Immunology

1. Isolation of IgG from serum using ion exchange chromatography.
2. Isolation of IgG from serum using affinity chromatography.
3. Separation of heavy and light chains of IgG.
4. Study of antigen-antibody interaction by double immunodiffusion.
5. Electrophoresis (SDS - PAGE) of purified IgG.
6. Immunoblotting
7. Rocket immunoassay.
8. Estimation of serum Igs by sandwich ELISA.
9. Hemagglutination assay.
10. Blood typing.

COMPONENT 2: Molecular Biology-II

1. Over-expression of your favorite gene (YFG) in bacterial system
   a. Induction of recombinant protein by IPTG
   b. Analysis on SDS-PAGE
2. Purification of protein on Ni-NTA column and analysis of purification by SDS-PAGE.
3. Isolation of RNA from yeast (or from any other organism)
4. RT-PCR analysis
5. Yeast two-hybrid analysis to investigate protein- protein interaction

COMPONENT 3: Studies on Mitochondria

1. Preparation of tightly coupled mitochondria from rat liver.
2. Estimation of protein in mitochondria and homogenate by Biuret method.

3. Estimation of SDH activity in mitochondria and homogenate and calculation of recovery of mitochondria (INT and DCIP methods).
4. Estimation of NADH dehydrogenase activity in mitochondria and homogenate and calculation of recovery of mitochondria.
5. Measurement of rate of respiration and oxidative phosphorylation in mitochondria using succinate, glutamate and malate as substrates.
6. Measurement of rate of respiration and oxidative phosphorylation in mitochondria using glutamate and malate as substrates using oxytherm respirometer.
7. Estimation of cytochrome oxidase activity in mitochondria
8. Estimation of cytochromes in mitochondria
9. Estimation of ATPase activity in mitochondria with and without uncouplers.
10. Separation of the components of electron transport chain using blue native page.

Elective Courses (Any two):

BC520: INTRODUCTORY BIOINFORMATICS - ELECTIVE COURSE- 2 CREDITS

Any Science Background Graduate

1. Why Bioinformatics? The success story as the introduction.
2. The sequence analysis: the fundamentals and the tools.
3. The protein sequence database and its features.
4. The measure of similarity- covers both sequence and structure.
5. The substitution matrices and their implications.
6. Several different search algorithms.
7. Using the results in experiments: the homology models
8. The structure database (pdb example)
9. Searching for structures.
10. Potential applications in drug discovery.
11. New approaches and computational tools.

COURSE NO: BC 521: ENDOCRINE BIOCHEMISTRY - ELECTIVE COURSE- 2 CREDITS

Endocrine system: General features, mechanism of action of hormones. Biosynthesis , structures and functions of the hormones of pituitary, thyroid, adrenal, pancreas and gonads-secretion, biochemical nature of hormones, regulation of secretion, mechanism of action and biological effects.
Digestive processes in various regions of digestive system. Gastrointestinal hormones, their synthesis and function.
Structure and function of Insulin like growth factors and their receptors.

COURSE NO: BC522 - PROTEOMICS-ELECTIVE COURSE- 2 CREDITS

INTRODUCTION TO PROTEOMICS:

Brief outlines of protein and nucleic acid (DNA and RNA) structures and their sequences.
Annotation of the genome, Protein expression studies, Protein function, Protein modifications, Protein localization and compartmentalization, Protein-protein interactions, Types of Proteomics- Protein expression proteomics, Structural proteomics, Functional proteomics, Clinical and therapeutic applications of proteomics

TECHNOLOGY OF PROTEOMICS
Separation and Isolation of Proteins, One- and two-dimensional gel electrophoresis (IEF and 2D electrophoresis), Alternatives to electrophoresis.

MASS SPECTROMETRY
(i) Sample preparation, (ii) Sample ionization, (iii) Mass analysis, (iv) Types of mass spectrometers, (v) Peptide fragmentation, (vi) Our approach to mass spectrometry.
Database Utilization. Peptide mass fingerprinting database searching. Amino acid sequence database searching
De novo peptide sequence information, Uninterpreted MS/MS data searching

PROTEOMICS APPLICATIONS
Characterization of Protein Complexes, Protein Expression Profiling, Expression profiling by two-dimensional electrophoresis, Isotope-coded affinity tags, Protein arrays, Proteomics Approach to Protein Phosphorylation, Phosphoprotein enrichment, Phosphorylation site determination by Edman degradation

Phosphorylation site determination by mass spectrometry
(i) Phosphopeptide sequencing by MS/MS
(ii) Analysis of phosphopeptides by MALDI-TOF
Yeast Genomics and Proteomics, Proteome Mining

COURSE NO: BC 523: DEVELOPMENTAL BIOLOGY–ELECTIVE COURSE- 2 CREDITS

1. Basic concepts of development : Potency, commitment, specification, induction, competency, determination and differentiation, morphogenetic gradients, cell fate and cell lineages, Stem Cells, genomic equivalence and the cytoplasmic determinants, imprinting; mutants and transgenics in analysis of development
2. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis.
3. Morphogenesis and organogenesis in animals: Animal models of Cell aggregation and differentiation, axes and pattern formation, organogenesis, eye lens induction, limb development and regeneration, differentiation of neurons, post embryonic development- larval formation, metamorphosis, environmental regulation of normal development.
4. Programmed cell death, aging and senescence.

Semester IV

COURSE NO: BC 551: NUTRITIONAL AND CLINICAL BIOCHEMISTRY-CORE COURSE- 3 CREDITS

Nutritional Biochemistry: Vitamins (fat soluble and water soluble vitamins), Trace Elements (Iodine, Fluorine, Zinc, Copper, Chromium, Cobalt, Selenium, Manganese and molybdenum) and

Mineral Metabolism, Essential fatty acids, nutrition and serum cholesterol levels, sucrose consumption and intolerance, lactose intolerance, Protein Calorie Deficiency Status, Food sources, RDA, metabolism, functions, deficiency and toxicity symptoms.

Disorders of lipid metabolism, Disorders of Carbohydrate metabolism, Disorders of Amino Acid metabolism, Food born diseases and their prevention, Porphyrins and Gout, Obesity, Diabetes Mellitus, and Atherosclerosis, Functional tests of kidney and liver.

Genetic and Chromosomal Abnormalities: Genetic disorders, Mutations, Diseases due to defected repair mechanisms, Mendelian Disorders, Transmission pattern of single gene disorders, Autosomal disorders, sex chromosome related disorders.
Cytogentic disorders, Trisomy of 21st chromosome, Down syndrome, Klinfelter syndrome, Turner syndrome, Fragile X Syndrome, Muscular Dystrophy and cystic fibrosis, Blood Disorders Immunodeficiency disorders. Autoimmunity.

Molecular Diagnostics: Basic techniques used in molecular diagnostics, future of molecular diagnostics, Fluorescent in-situ hybridization for identification of chromosomal abnormalities.

Pre Clinical Studies: Pre clinical Models (Drug discovery and development, including animal studies, tissue culture studies, safety, efficacy), Assessment of pharmacokinetics in early phase drug evaluation, Metabolism studies: *in vitro* and *in vivo* tests, Pharmacogenomics, Bioanalytical techniques.

COURSE NO: BC 552: BIOCHEMICAL TECHNIQUES-IV-CORE COURSE- LAB (2 CREDITS)
Clinical Biochemistry

1. Estimation of blood glucose.
2. Estimation of cholesterol in serum.
3. Estimation of Bilirubin in serum
4. Estimation of creatine in serum.
5. Estimation of creatinine in serum.
6. Estimation of urea in blood & urine
7. Estimation of uric acid in serum
8. Estimation of iron in serum.
9. Estimation of Transaminases (SGOT and SGPT) in serum.
10. Estimation of G-6-P Phosphatase in serum.
11. Estimation of LDH in serum.
12. Estimation of triglycerides in serum.

COURSE NO: BC 553: PROJECT WORK- 8 CREDITS

Elective Courses

COURSE NO: BC 571: PROTEIN PHOSPHORYLATION AND SIGNAL TRANSDUCTION-ELECTIVE COURSE- 2 CREDITS

1. Protein Kinases and phosphatases. The importance of protein phosphorylation in the regulation of activities of various proteins involved in various metabolic pathways.
2. Specific receptors that mediate the response of cells to extracellular signals such as hormones, calcium ions, insulin and glucagons.

3. Ca 2+ ions, Inositol triphosphate and Diacyl glycerol as second messengers for certain cellular signals.
4. Growth factors steroid hormones and their receptors.
5. Cell-to-cell signaling in microorganisms importance of pheromones and aggregation; wound induced signals in plants.
6. Electrical signals; action potential; changes in permeability of membranes to specific ions.
7. Neurotransmitters catecholamines, GABA, Endorphins and Enkephalins
8. Cyclic GMP and AMP as transducing molecules.

COURSE NO: BC 575: PRINCIPLES IN CANCER AND CANCER STEM CELL BIOLOGY-ELECTIVE COURSE- 2 CREDITS

1. Normal cell versus Cancer cell
2. Cell immortalization and tumorigenesis
3. Oncogenes and tumor suppressor genes
4. Maintenance of Genomic integrity and development of cancer
5. Invasion and metastasis- Epithelial to mesenchymal transition
6. Cancer stem cells-Basics and how to targeting cancer stem cells
7. Rationale treatment of cancer
8. Special emphasis on few imp cancers which are prevalent in India- Breast cancer, Oral cancer, etc