DEPARTMENT OF BIOCHEMISTRY

School of Life Sciences

University of Hyderabad

Syllabus

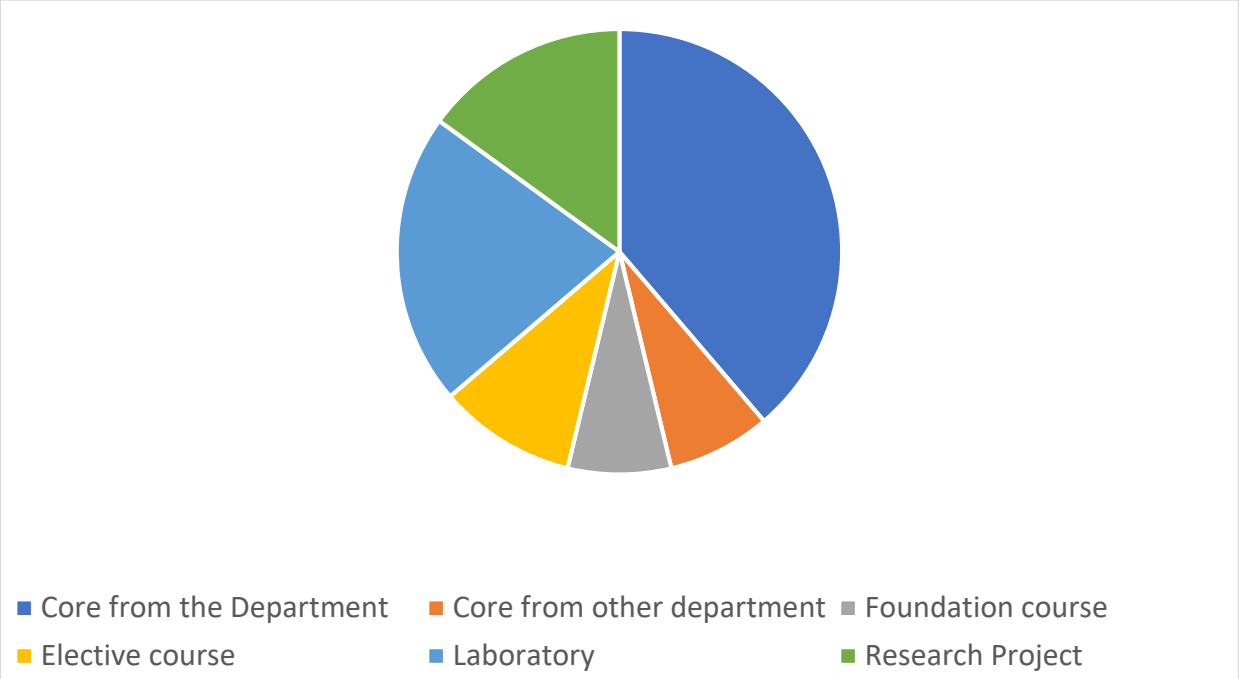
for

M. Sc. in Biochemistry

Salient features of the curriculum:

- Choice based credit system
- Total 80 credits: 68% theory; 32% laboratory based
- 31 theory credits from the department- compulsory core
- 6 theory credits from other departments
- 14 choice based credits from across the discipline
- In-house research project for one year

Distribution of credits:



This syllabus is approved in Departmental Council on 5/3/2019 and in School Board on18/3/2019

M.Sc. Biochemistry
Course Structure

Semester: I

S.No.	Course No.	Course Title	Credits
1	BC401	Intermediary Metabolism I	3
2	BC402	Biophysical Chemistry	3
3	BC403	Basic Bioinformatics and Computational Biology	3
4	BC404	Biochemical Techniques - I	4
5	PB401	Genetics	3
6	PB402	Microbiology	3
7		Foundation course 1	3
		Total	**22**

Semester: II

S.No.	Course No.	Course Title	Credits
1	BC451	Enzymology	3
2	BC452	Molecular Biology - I	3
3	BC453	Structural Biology	2
4	BC454	Intermediary Metabolism - II	3
5	BC455	Biochemical Techniques - II	5
6	BC456	Cell Biology	3
7		Foundation course 2	3
		Total	**22**

Semester: III

S.No.	Course No.	Course Title	Credits
1	BC501	Basic Immunology	3
2	BC502	Molecular Biology - II	3
3	BC503	Bioenergetics and Biomembranes	3
4	BC504	Biochemical Techniques - III	5
5	BC521	Endocrine Biochemistry (Elective)	2
6	BC523	Developmental Biology (Elective)	2
		Total	**18**

Semester: IV

S.No.	Course No.	Course Title	Credits
1	BC551	Nutritional and Clinical Biochemistry	2
2	BC553	Project	12
3	BC575	Principles in Cancer and Cancer Stem Cell Biology (Elective)	2
4	BC576	Glycoconjugate: Role in Biology and Biomedical Relevance (Elective)	2
		Total	18

SEMESTER – I

INTERMEDIARY METABOLISM – I

COURSE NO: BC 401 (3 CREDITS) CORE

Carbohydrates (23 hours)

1. Dietary Carbohydrates – Digestion and absorption from the intestinal tract into other parts of the body - 3h
2. Reactions of glycolysis and TCA cycle with emphasis on regulation, anaplerotic reactions, tracing reactions of TCA cycle using radio isotopes pyruvate dehydrogenase complex and its mechanism substrate level phosphorylation, lactate fermentation, malate/aspartate shuttle, glycerol-phosphate shuttle, and Warburg effect. Glyoxylate cycle - 6 h
3. General scheme of carbohydrate metabolism in liver and extra-hepatic tissues, phosphorylation of glucose, glycogen synthesis and glycogenolysis and their regulation in liver and muscle. Including inborn errors of carbohydrate metabolism - 5h
4. Special emphasis on the interrelations between metabolic pathways and human diseases such as diabetes and obesity arise from defects in metabolic pathways. Biosynthesis of Lactose, Starch and Cellulose - 2h
5. The reactions of gluconeogenesis, hormonal and metabolite control of glycolysis and gluconeogenesis in liver. The pentose phosphate pathway reactions and its importance. metabolic role: source or disposal of pentoses, reducing power for biosynthesis - 4h
6. Hormonal regulation of blood glucose: insulin, glucagon, cortisol, defects in glycaemia control and altered metabolic events; non-enzymatic glycation and polyol pathway - 3h

Reference Books:

1. Biochemistry – Author - Lubert Stryer
2. Lehninger - Principles of Biochemistry
3. Text Book of Biochemistry Authors ES West, WR Todd, HS Mason and JT Van Bruggen
4. Review of Physiological Chemistry Author - Harold Anthony Harper

Lipids (15 hours)

1. Structure of important lipids. Digestion, absorption and transport of dietary lipids, role of bile salts, hormone-dependent triglyceride lipase - 2h
2. Fatty acid activation, transport to the mitochondrial matrix and role of carnitine, steps of beta-oxidation. Oxidation of odd-chain and of unsaturated fatty acids, energetics of fatty acids oxidation, fasting and ketogenesis and relation with gluconeogenesis - 3h
3. De novo synthesis of palmitate, energetics and reducing power. Elongation and desaturation of fatty acids, essential fatty acids and derivatives (ω3 and ω6 families) - 2h
4. Biosynthesis of glycerol lipids, synthesis of phosphatidic acid. Synthesis of triacylglycerols and the major glycerophospholipids. Brief account on the synthesis of plasmalogens, sphingomyelin and glycolipids. Brief account of Prostaglandins - 3h
5. Reactions of cholesterol biosynthesis, synthesis of cholesteryl esters. Derivatives of cholesterol: bile acids, vitamin D3, and steroid hormones. Structure and classification of lipoproteins, composition, transport, and cholesterol export in lipoproteins - 3h
6. Hormonal regulation of lipid levels, cholesterol synthesis and lipoproteins. Defects in fatty acid metabolism in relation to obesity and metabolic syndrome, connection between glucose and fatty acid metabolism; Randle cycle, inborn errors in lipid metabolism - 2h

BIOPHYSICAL CHEMISTRY

COURSE NO: BC 402 (3 CREDITS) CORE

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
8. Understanding biological system using physical chemistry: signal transduction, rhodopsin, Bacteriorhodopsin, membrane potential, transporter and channels

Reference Books:

1. Physical Biochemistry by David Frefeilder
2. Physical Biochemistry Principles and Application by David Sheehan
3. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker
4. Physical Chemistry of Macromolecules Basic Principles and Issues by S. F. Sun

BASIC BIOINFORMATICS AND COMPUTATIONAL BIOLOGY- THEORY CUM LAB COURSE

COURSE NO: BC 403 (3 CREDITS) CORE

Module 1: (Theory 12 hours + Lab 24 hours)

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 modelling: RCSB PDB database, Protein tertiary structure prediction using homology modelling and threading, small molecules, force fields, energy minimization and molecular docking
8. Applications to biological problem solving

Module 2: (Theory 12 hours)

Statistical analysis of biological experiments:

1. Samples and Populations, Measures of central tendency and dispersal (1 h)
2. Sampling distribution (1h)
3. Probability distributions (Binomial, Poisson and Normal) (1h)
4. Confidence Interval (1h)
5. Difference between parametric and non-parametric statistics (1h)
6. Levels of significance: Null hypothesis, Alternative hypothesis (2 h)
7. Errors (Type I and type II errors) (2h)
8. p-value, adjusted p-value; Student's T-test (2h)
9. Regression and Correlation; Analysis of variance; $\chi 2$ test (1h)

Reference Books:

1. Attwood,T. and Parry-Smith, D. Introduction to Bioinformatics. Pearson Education Asia. 2001. ISBN:978-0582327887
2. Krane, D.E. and Raymer, M.L. Fundamental Concepts of Bioinformatics. Pearson Education. 2003. ISBN:978-8177587579
3. Essential Medical Statistics by Betty R. Kirkwood and Jonathan S.C. Sterne, Blackwell Publishing ISBN-13: 978-0865428713
4. Schaum's Outline Series on Statistics, 4th Edition
5. Biostatistics For Dummies by John Pezzullo, John Wiley & Sons, ISBN-13: 978- 1118553985

BIOCHEMICAL TECHNIQUES-I-LAB

COURSE NO: BC 404 (4 CREDITS) CORE

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

GENETICS

COURSE NO: PB 401
(3 CREDITS)
CORE

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.

Reference Books:

1. Introduction to genetic analysis by Griffiths etal
2. iGenetics by Russell
3. Genetics: analysis of genes and genomes by Hartl and Jones
4. Molecular Biology of the Gene by Watson et al

MICROBIOLOGY

COURSE NO: PB 402 (3 CREDITS) CORE

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

Reference Books:

1.Microbiology edited by Prescott

2.Microbiology edited by Torfora

3.Microbiology edited by Peltzar

4.Microbiology edited by Stanier

5.Biology of Microorganisms edited by M.T.Medican, J.M.Martiniko and J.Parker

FOUNDATION COURSE

CHEMISTRY AND PHYSICS OF BIOLOGY

COURSE NO: FN 120 (3 CREDITS) FOUNDATION

Unit 1: Historical prospective of physical, chemical and biological discoveries for the advancement of life processes in last 10 decades

Unit 2: Chemical context of living systems; Chemistry of life; Foundational Concepts of Structure from Chemistry; Water and life; the water molecule is polar; Properties of water; Ionization of water; Carbon and life, Organic chemistry-the study of carbon compounds; what makes carbon special? Properties of organic compounds; Foundational Concepts of Reactions from Chemistry; Structure and function of biomolecules, the emergence of order from sequence

Unit 3: Physics and Life, Physical basis of life: Theory of fundamental structure of protoplasm, Principles of a complex adaptive system, Foundational Mechanical Concepts from Physics, Foundational Energy and Thermodynamic Concepts from Physics and Chemistry

Unit 4: Use of computational tools for investigating the biological problems; Biostatistics

Unit 5: Recent developments in the Biochemistry

SEMESTER – II

ENZYMOLOGY

COURSE NO: BC 451 (3 CREDITS) CORE

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.

Reference Books:

1.Fundamentals of Enzymology, The cell and molecular basis of catalytic proteins - Nicholas C Price and Lewis Stevens, Oxford University Press.

2.Trevor Palmer and Philip Bonner, Enzymes: Biochemistry, Biotechnology, Clinical Chemistry., East-West Press Private Limited, New Delhi, 2nd Edition, 2008.

3.Robert A. Copeland, Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis. Wiley-VCH, Inc. NY, 2nd Edition, 2000

4.Biochemistry, Garrett and Grisham

5.Biochemistry, Berg, Tymoczko and Stryer

MOLECULAR BIOLOGY – I

COURSE NO: PB 452 (3 CREDITS) CORE

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]

Reference Books:

1.Genomes 3 by T. A. Brown

2.Molecular Biology by D. Freifelder, latest edition

3.Molecular Biology of the Gene by J. D. Watson et al., latest edition

4.Molecular Biology of the Cell by Lodish et al., latest edition

5.Recombinant DNA by J. D. Watson, latest edition

6. Reviews and original research articles from journals

STRUCTURAL BIOLOGY

COURSE NO: PB 453 (2 CREDITS) CORE

1. Structure of Biomolecules: Proteins Structures: Introduction and General Overview, Secondary, tertiary and quaternary structure of protein, super secondary structure, Ramachandran plot, protein folding
2. Structural overview of nucleic acids. 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. Primary and secondary structure of RNA: Watson-Crick and Hoogsteen base pairing and Primary and secondary structure DNA: A-DNA, B-DNA, C-DNA conformation, DNA-RNA hybrids, Z-DNA formation.
4. Spectroscopic technique –II: Basic principle of 1. Circular Dichroism Spectroscopy (CD and ORD), 2. ESR, 3. IR 4. Raman and 5. SPR.
5. Techniques used for structural analysis of proteins and nucleic acid: X-ray Crystallography (Symmetry, space group crystal lattices, brag's law in real & reciprocal space), Nuclear magnetic resonance (NMR) and Cryo-electron-microscopy, their limitation and precautions. Mass spectrometry

Reference Books:

1. Protein Structures and Molecular properties by Thomas C Creighton
2. Principles of nucleic acid Structure by Charles R Cantor
3. Physical Biochemistry Principles and Application by David Sheehan
4. Crystallography made crystal clear by Gale Rhodes
5. Outline of Crystallography for Biologists by David Blow

INTERMEDIARY METABOLISM –II

COURSE NO: BC 454 (3 CREDITS) CORE

Protein and Metabolism (20 hours)

1. Dietary protein digestion and absorption of amino acids, intracellular protein degradation, nonoxidative and oxidative deamination, mechanism of transaminase reactions. 3h
2. Fate of ammonia in extra hepatic tissues, glutamine synthesis and transport, alanine cycle, urea cycle reactions and regulation. Biological nitrogen fixation. 3h
3. Fate of the carbon skeleton of amino acids, glucogenic and ketogenic amino acids, relation with TCA cycle and lipogenesis. Amino acid decarboxylation: biogenic amines, polyamines. 5h
4. Biosynthesis of amino acids. Synthesis of essential and non-essential amino acids and regulation of amino acid biosynthesis. Precursor functions of amino acids including Porphyrin metabolism. 7h
5. Inborn errors of amino acid metabolism. 2h

Nucleic acids & Xenobiotic Metabolism (16 hours)

6. Degradation of nucleic acids: deoxyribonucleases and ribonucleases. Nucleotide biosynthesis: de novo purine ribonucleotide biosynthesis and its regulation, purine ribonucleotide biosynthesis from purine bases and ribonucleosides (salvage pathway). Inter conversion of purine ribonucleotides, catabolism of purine bases. 3h
7. Pyrimidine ribonucleotide metabolism: de novo biosynthesis of pyrimidine ribonucleotides and regulation, pyrimidine ribonucleotide biosynthesis from bases and ribonucleotides (salvage pathway). Catabolism of pyrimidine bases. 4h
8. Regulation of purine and pyrimidine nucleotide metabolism; Formation of NDPs and NTPs; Biosynthesis of deoxy-ribonucleotides and its regulation; Inborn errors of nucleotide metabolism; Nucleotide coenzymes. Inborn errors of nucleotide metabolism. 4h
9. Metabolism of 1C units, role of FH4. Methionine and methyl group transfer, Role of vitamin B12 in nucleic acid synthesis. 3h
10. Xenobiotic metabolism: Significance; Phases of xenobiotic metabolism; Types of reactions involved. 2h

Reference Books:

1. Principles of Biochemistry Authors - Abraham White, Philip Handler and Emil L. Smith
2. Lehninger Principles of Biochemistry
3. Biochemistry – Author - Lubert Stryer
4. Review of Physiological Chemistry Author - Harold Anthony Harper

BIOCHEMICAL TECHNIQUES-II-LAB COURSE

COURSE NO: BC 455 (5 CREDITS) CORE

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 favourite 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.

COMPONENT 4: 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

CELL BIOLOGY

COURSE NO: BC 456 (3 CREDITS) CORE

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)

Reference Books:

1.Molecular Biology of the Cell by Bruce Alberts et al

2. Molecular Cellular Biology by Lodish et al

3. Relevant reviews and original research papers that would be discussed and distributed in class.

FOUNDATION COURSE

BASIC BIOINFORMATICS AND COMPUTATIONAL BIOLOGY

COURSE NO: FN 214 (3 CREDITS) FOUNDATION

1. Introduction to Bioinformatics and Computational Biology: History and major developments

2. Introduction to Genes, Genomes, Replication, Transcription and Translation processes in eukaryotes and prokaryotes.

3. Introduction to sequence, structure, pathways, and other biological databases and computational tools

4. Nucleic acid sequence analysis: Sequence alignment, substitution matrices

5. Protein sequence analysis: Sequence alignment, substitution matrices, secondary structure elements, motifs, folds and domains

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, Secondary and tertiary structure prediction

8. Applications to biological problem solving

Reference Books:

1.Krane, D.E. and Raymer, M.L. Fundamental Concepts of Bioinformatics. Pearson Education. 2003. ISBN:978-8177587579

2.James D. Watson *et al.*, Molecular Biology of the Gene, 7th Edition, Pearson Education. ISBN 13: 978- 9332585478

SEMESTER III

BASIC IMMUNOLOGY

COURSE NO: BC 501 (3 CREDITS) CORE

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.

Reference Books:

1.Kuby Immunology; 10th edition; Authors: Owen, Punt, Stranford

2.Wiley: Roitt's Essential Immunology; 13th edition; Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt

3.ELSEVIER: Cellular and Molecular Immunology, 9th Edition; Authors: Abul Abbas, Andrew H. Lichtman, Shiv Pillai

4.Lippincott Williams & Wilkins: Fundamental Immunology By Willium E.Paul; 7th edition

5.Taylor & Francis group: Janeway's Immunobiology; 9th Edition

6.Reviews from journals

MOLECULAR BIOLOGY –II

COURSE NO: BC 502 (3 CREDITS) CORE

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]
5. Exon shuffling, RNA editing and different RNAs and their functions (including siRNA, microRNa and dsRNA, long non-coding RNA), Riboswitch. [3 hours]
6. Translation, ribosome, initiation, elongation and termination steps in protein synthesis, regulation of factors and translation. [4 hours]
7. Secretory Protein biosynthesis, Covalent modifications of proteins (Glycosylation, iodination, methylation, oxidation, phosphorylation etc.) [3 hours]
8. DNAse hypersensitivity, Random and Site-specific mutagenesis, DNA foot printing, finger printing, RFLP, RNA synthesis, polysomes, Protein synthesis in vitro. [3 hours].
9. Methods for studying RNA and transcriptome: northern hybridization; RT-PCR; microarray analysis; SAGE. [3 hours]
10. Studying protein-protein interaction: Yeast two hybrid systems, Co-immunoprecipitation; GST-pull down; FRET and SPR (Surface Plasmon Resonance) [2 hours]

Reference Books:

1.Genomes 3 by T. A. Brown

2.Lewin's Genes by J. E. Krebs et al., latest edition

3.Molecular Biology of the Gene by J. D. Watson et al., latest edition

4.Molecular Biology of the Cell by Lodish et al., latest edition

5.A genetic switch: phage lambda revisited by M. Ptashne

6. Reviews and original research articles from journals

BIOENERGETICS AND BIOMEMBRANES

COURSE NO: BC 503 (3 CREDITS) CORE

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, c, a, and a, 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 (ΔG ') and its relationship to products to substrate ratio. Additive nature of ΔG ', 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. ASmino acid transport and glucose transporters. Anion and cation symport and antiport systems.
5. Active transport in bacteria, Group translocation, lactose permease for lactose transport.

Reference Books:

1.Biochemistry by Reginald H. Garrett/Charles M. Grisham, 6th Edition

2.Principles of Biochemistry by Lehninger , 7th Edition

BIOCHEMICAL TECHNIQUES-III-LAB

COURSE NO: BC 504 (5 CREDITS) CORE

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

ENDOCRINE BIOCHEMISTRY

COURSE NO: BC 521 (2 CREDITS) ELECTIVE

1. 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.

2. Digestive processes in various regions of digestive system. Gastrointestinal hormones, their synthesis and function.

3. Structure and function of Insulin like growth factors and their receptors.

Reference Books:

1.Text book if endocrine physiology by James E Griffin and Sergio R Ojeda

2.Endocrinology by Mac Hadley

3.Williams Text book of endocrinology

DEVELOPMENTAL BIOLOGY

COURSE NO: BC 523 (2 CREDITS) ELECTIVE

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.

Reference Books:

1. Developmental Biology by Scott F. Gilbert

2. Developmental Biology: A very Short Introduction by Lewis Wolpert

3. Fundamental Concepts of Developmental Biology by Das N.

SEMESTER – IV

NUTRITIONAL AND CLINICAL BIOCHEMISTRY

COURSE NO: BC 551 (2 CREDITS) CORE

1. An overview of specific aspects of metabolism in different organs and tissues (brain, kidney, liver, skeletal muscle, heart, adipose tissue, blood). 2h
2. General concepts and nutritional requirements of proteins and calories for growth, maintenance and physiologically altered states, nitrogen balance and muscle protein turnover. 2h
3. Disorders of carbohydrates: Diabetes mellitus, non-enzymatic glycation, sorbitol formation, glycohemoglobins, hypoglycemias, galactosemia, various types of glucose tolerance tests, glycogen storage diseases. 2h
4. Disorders of lipids metabolism: Plasma lipoproteins, cholesterol, triglycerides & phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's and Niemann-Pick disease, ketone bodies. 2h
5. Biochemistry of fasting and feeding conditions, interrelations between metabolic pathways, interrelations between liver and peripheral tissues, alcohol metabolism. 2h
6. Malnutrition – Prevention of malnutrition, improvement of diets. Recommended dietary allowances, nutritive value of common foods. Protein-calorie malnutrition. Requirement of proteins and calories under different physiological states- infancy, childhood, adolescence, pregnancy, and lactation. 3h
7. Hypo- and hyperthyroidism and goiter, hypo- and hyper-adrenocorticism, hypo- & hyper- pituitarism, haemoglobinopathies; anemia, thalassemia, sickle cell anemia, jaundice, rheumatoid arthritis; kidney and liver function tests. 3h
8. Scope of clinical biochemistry in diagnosis, collection and preservation of biological fluids (blood, urine & CSF), normal values of important constituents of blood, CSF and urine. Collection preparation, preservation, and handling of clinical samples, quality control, Safety measures in clinical laboratory. 3h
9. Principles of diagnostic enzymology; definition of functional and non-functional plasma enzymes, problems of enzyme assay in clinical biochemistry laboratory; factors affecting enzyme levels in plasma or serum; selection of enzyme tests; enzyme and enzymes pattern in health and diseases with special mention of plasma lipase, amylase, cholinesterase; alkaline and acid phosphates, SGOT, SGPT, LDH & CPK. 3h

Reference Books:

1. Nutritional Elements and Clinical Biochemistry by A. Brewster & Marge

2. Nutritional Biochemistry and Metabolism: With Clinical Applications by Maria C Linder

3. Handbook of Nutritional Biochemistry: Genomics, Metabolomics and Food Supply by Sondre Haugen and Simen Meijer

ELECTIVE COURSES

PRINCIPLES IN CANCER AND CANCER STEM CELL BIOLOGY

COURSE NO: BC 575
(2 CREDITS)
ELECTIVE

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 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

Reference Books:

1.Biology of Cancer by Robert Weinberg

2.Principles Of Cancer Biology - Lewis J Kleinsmith

3. Oxford Textbook of Cancer Biology. Edited by Francesco Pezzella, Mahvash Tavassoli and David Kerr.

4. Cancer Biology by Raymond Ruddon

GLYCOCONJUGATES: ROLE IN BIOLOGY AND BIOMEDICAL RELEVANCE

COURSE NO: BC 576 (2 CREDIT) ELECTIVE

1. Carbohydrates and Glycoconjugates
Definition/terminology properties-hemiacetal/acetal – glycosidic linkages – classes of glycoconjugates - non-enzymatic glycation - *Diabetes mellitus.*
I Cell Disease: A human disorder caused by the deficiency of a carbohydrate recognition marker- mammalian lectin – lysosomes - protein sorting - receptors - enzyme replacement. (4 h)

2. N-Glycosylation Glycosylating precursors - membrane transporter- transferases - processing glycosidases - topology – frequency – heterogeneity Lecture
Protein quality control in the endoplasmic reticulum: Role of N-glycosylation – sensing of misfolded proteins – export of misfolded glycoproteins–proteasomal degradation- stress reaction, Purification of glycosidases. (5 h)

3. O-Glycosylation Mucins–notch/fringe signalling–collagen-nucleo cytoplasmic glycosylation. Proteoglycans and Hyaluronan Diversity - properties – biological functions - blood clotting and heparin – binding partners, Fucosylation disorders. (3 h)

4. Congenital Disorders of Glycosylation: A rapidly emerging group of disorders, Glycolipids (A) and Blood Groups (B) Biosynthesis, genetics and applications. (3h)

5. Lectins: I
Definition, occurrence, lectin folds, structure/function of mammalian lectins and other lectins. Purification of plant and animal lectins.

6. Lectins: II
Mammalian and other lectins, viral lectins, biology and medical aspects of the influenza virus, bacterial adhesins (Helicobacter pylori) and toxins (cholera and neurotoxins). (7 h)

7. GPI-anchored proteins, Biosynthesis and degradation of glycoconjugates, Lysosomal storage diseases. (2 h)

Reference Books:

1. Essentials of Glycobiology Ajith Varki
2. Affinity Chromatography by PG Dean et al.
3. Lehninger Principles of Biochemistry David L Nelson, Michael M. Cox

PROJECT WORK

COURSE NO: BC 553 (12 CREDITS) CORE

DEPARTMENT OF BIOCHEMISTRY

School of Life Sciences

University of Hyderabad

Syllabus

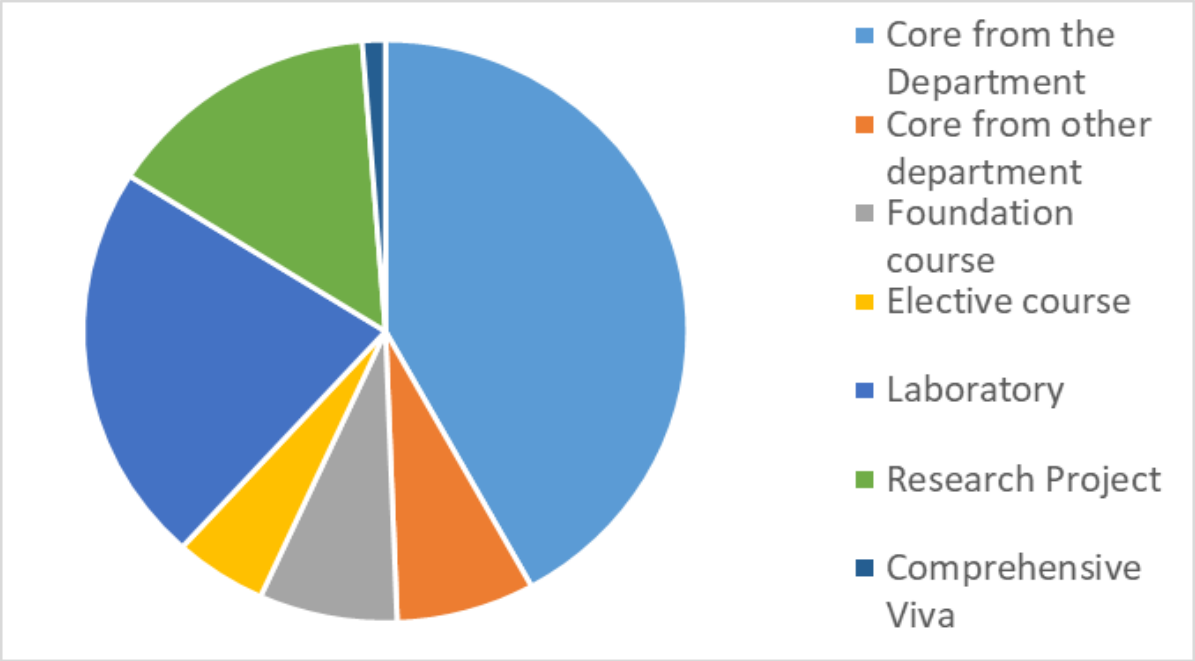
for

Integrated M. Sc.- Ph. D. in Biochemistry and Molecular Biology

Salient features of the curriculum:

- Choice based credit system
- Total 80 credits: 62% theory; 38% laboratory based
- 34 theory credits from the department- compulsory core
- 6 theory credits from other departments
- 10 choice based credits from across the discipline
- In-house research project for one year

Distribution of credits:



This syllabus is approved in Departmental Council on 5/3/2019 and in School Board on18/3/2019

Integrated M.Sc.-Ph.D. Biochemistry and Molecular Biology
Course Structure

Semester: I

S.No.	Course No.	Course Title	Credits
1	BC401	Intermediary Metabolism I	3
2	BC402	Biophysical Chemistry	3
3	BC403	Basic Bioinformatics and Computational Biology	3
4	BC404	Biochemical Techniques - I	4
5	PB401	Genetics	3
6	PB402	Microbiology	3
7		Foundation Course - 1	3
		Total	**22**

Semester: II

S.No.	Course No.	Course Title	Credits
1	MB451	Enzymology and Bioenergetics	3
2	BC452	Molecular Biology - I	3
3	BC453	Structural Biology	2
4	BC454	Intermediary Metabolism - II	3
5	BC455	Biochemical Techniques - II	5
6	BC456	Cell Biology	3
7		Foundation Course - 2	3
		Total	**22**

Semester: III

S.No.	Course No.	Course Title	Credits
1	BC501	Basic Immunology	3
2	BC502	Molecular Biology - II	3
3	MB503	Molecular Biology -III	3
4	BC504	Biochemical Techniques - III	5
5	BC521	Endocrine Biochemistry **(Elective)**	2
6	BC523	Developmental Biology **(Elective)**	2
		Total	**18**

Semester: IV

S.No.	Course No.	Course Title	Credits
1	BC551	Nutritional and Clinical Biochemistry	2
2	BC553	Project	12
3	MB576	Molecular Biology- IV	3
4	MB578	Advanced molecular biology practical	1
5	MB579	Comprehensive viva	1
		Total	**19**

SEMESTER – I

INTERMEDIARY METABOLISM – I

COURSE NO: BC 401 (3 CREDITS) CORE

Carbohydrates (23 hours)

1. Dietary Carbohydrates – Digestion and absorption from the intestinal tract into other parts of the body - 3h
2. Reactions of glycolysis and TCA cycle with emphasis on regulation, anaplerotic reactions, tracing reactions of TCA cycle using radio isotopes pyruvate dehydrogenase complex and its mechanism substrate level phosphorylation, lactate fermentation, malate/aspartate shuttle, glycerol-phosphate shuttle, and Warburg effect. Glyoxylate cycle - 6 h
3. General scheme of carbohydrate metabolism in liver and extra-hepatic tissues, phosphorylation of glucose, glycogen synthesis and glycogenolysis and their regulation in liver and muscle. Including inborn errors of carbohydrate metabolism - 5h
4. Special emphasis on the interrelations between metabolic pathways and human diseases such as diabetes and obesity arise from defects in metabolic pathways. Biosynthesis of Lactose, Starch and Cellulose - 2h
5. The reactions of gluconeogenesis, hormonal and metabolite control of glycolysis and gluconeogenesis in liver. The pentose phosphate pathway reactions and its importance. metabolic role: source or disposal of pentoses, reducing power for biosynthesis - 4h
6. Hormonal regulation of blood glucose: insulin, glucagon, cortisol, defects in glycaemia control and altered metabolic events; non-enzymatic glycation and polyol pathway - 3h

Lipids (15 hours)

1. Structure of important lipids. Digestion, absorption and transport of dietary lipids, role of bile salts, hormone-dependent triglyceride lipase - 2h
2. Fatty acid activation, transport to the mitochondrial matrix and role of carnitine, steps of beta-oxidation. Oxidation of odd-chain and of unsaturated fatty acids, energetics of fatty acids oxidation, fasting and ketogenesis and relation with gluconeogenesis - 3h
3. De novo synthesis of palmitate, energetics and reducing power. Elongation and desaturation of fatty acids, essential fatty acids and derivatives (ω3 and ω6 families) - 2h
4. Biosynthesis of glycerol lipids, synthesis of phosphatidic acid. Synthesis of triacylglycerols and the major glycerophospholipids. Brief account on the synthesis of plasmalogens, sphingomyelin and glycolipids. Brief account of Prostaglandins - 3h
5. Reactions of cholesterol biosynthesis, synthesis of cholesteryl esters. Derivatives of cholesterol: bile acids, vitamin D3, and steroid hormones. Structure and classification of lipoproteins, composition, transport, and cholesterol export in lipoproteins - 3h
6. Hormonal regulation of lipid levels, cholesterol synthesis and lipoproteins. Defects in fatty acid metabolism in relation to obesity and metabolic syndrome, connection between glucose and fatty acid metabolism; Randle cycle, inborn errors in lipid metabolism - 2h

Reference Books:

1. Biochemistry – Author - Lubert Stryer
2. Lehninger - Principles of Biochemistry
3. Text Book of Biochemistry Authors ES West, WR Todd, HS Mason and JT Van Bruggen
4. Review of Physiological Chemistry Author - Harold Anthony Harper

BIOPHYSICAL CHEMISTRY

COURSE NO: BC 402 (3 CREDITS) CORE

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
8. Understanding biological system using physical chemistry: signal transduction, rhodopsin, Bacteriorhodopsin, membrane potential, transporter and channels

Reference Books:

1. Physical Biochemistry by David Frefeilder
2. Physical Biochemistry Principles and Application by David Sheehan
3. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker
4. Physical Chemistry of Macromolecules Basic Principles and Issues by S. F. Sun

BASIC BIOINFORMATICS AND COMPUTATIONAL BIOLOGY- THEORY CUM LAB COURSE

COURSE NO: BC 403 (3 CREDITS) CORE

Module 1: (Theory 12 hours + Lab 24 hours)

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 modelling: RCSB PDB database, Protein tertiary structure prediction using homology modelling and threading, small molecules, force fields, energy minimization and molecular docking
8. Applications to biological problem solving

Module 2: (Theory 12 hours)

Statistical analysis of biological experiments:

1. Samples and Populations, Measures of central tendency and dispersal (1 h)
2. Sampling distribution (1h)
3. Probability distributions (Binomial, Poisson and Normal) (1h)
4. Confidence Interval (1h)
5. Difference between parametric and non-parametric statistics (1h)
6. Levels of significance: Null hypothesis, Alternative hypothesis (2 h)
7. Errors (Type I and type II errors) (2h)
8. p-value, adjusted p-value; Student's T-test (2h)
9. Regression and Correlation; Analysis of variance; $\chi 2$ test (1h)

Reference Books:

1. Attwood,T. and Parry-Smith, D. Introduction to Bioinformatics. Pearson Education Asia. 2001. ISBN:978-0582327887
2. Krane, D.E. and Raymer, M.L. Fundamental Concepts of Bioinformatics. Pearson Education. 2003. ISBN:978-8177587579
3. Essential Medical Statistics by Betty R. Kirkwood and Jonathan S.C. Sterne, Blackwell Publishing ISBN-13: 978-0865428713
4. Schaum's Outline Series on Statistics, 4th Edition
5. Biostatistics For Dummies by John Pezzullo, John Wiley & Sons, ISBN-13: 978- 1118553985

BIOCHEMICAL TECHNIQUES-I-LAB

COURSE NO: BC 404 (4 CREDITS) CORE

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

GENETICS

COURSE NO: PB 401 (3 CREDITS) CORE

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.

Reference Books:

1. Introduction to genetic analysis by Griffiths etal
2. iGenetics by Russell
3. Genetics: analysis of genes and genomes by Hartl and Jones
4. Molecular Biology of the Gene by Watson et al

MICROBIOLOGY

COURSE NO: PB 402
(3 CREDITS)
CORE

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

Reference Books:

1.Microbiology edited by Prescott

2.Microbiology edited by Torfora

3.Microbiology edited by Peltzar

4.Microbiology edited by Stanier

5.Biology of Microorganisms edited by M.T.Medican, J.M.Martiniko and J.Parker

FOUNDATION COURSE

CHEMISTRY AND PHYSICS OF BIOLOGY

COURSE NO: FN 120
(3 CREDITS)
FOUNDATION

Unit 1: Historical prospective of physical, chemical and biological discoveries for the advancement of life processes in last 10 decades

Unit 2: Chemical context of living systems; Chemistry of life; Foundational Concepts of Structure from Chemistry; Water and life; the water molecule is polar; Properties of water; Ionization of water; Carbon and life, Organic chemistry-the study of carbon compounds; what makes carbon special? Properties of organic compounds; Foundational Concepts of Reactions from Chemistry; Structure and function of biomolecules, the emergence of order from sequence

Unit 3: Physics and Life, Physical basis of life: Theory of fundamental structure of protoplasm, Principles of a complex adaptive system, Foundational Mechanical Concepts from Physics, Foundational Energy and Thermodynamic Concepts from Physics and Chemistry

Unit 4: Use of computational tools for investigating the biological problems; Biostatistics

Unit 5: Recent developments in the Biochemistry

SEMESTER – II

ENZYMOLOGY AND BIOENERGETICS

COURSE NO: MB 451 (3 CREDITS) CORE

1. Enzymes: basic definitions. Nomenclature (EC recommended and classical), enzyme purification, enzyme activity, specific activity and turnover number.
2. Bioenergetics and enzymes: Energy as understood by biochemist, energy transformations in living systems, activation energy, standard free energy change ($\Delta G^{0'}$) and its relationship to products to substrate ratio. Additive nature of $\Delta G^{0'}$, calculations of free energy change (ΔG) of few common reactions.
3. Enzyme kinetics: Single substrate-single intermediate. Michaelis-Menten and Lineweaver-Burk plots. Graphical analysis of kinetic data. Determination of Vmax and Km-Experimental aspects.
4. Enzyme inhibition and mechanism: Mechanisms of enzyme activity and rate, studies. Degree of inhibition. competitive, non-competitive and uncompetitive inhibition. Two substrate reactions. Sequential and Ping-pong mechanisms.
5. Allosteric enzymes: subunit interactions, Jocob and Monod model of allosteric enzymes. Koshland model, detailed discussion using haemoglobin, ATcase (effects of ATP and CTP) as examples. Single and Double displacement reactions.
6. Industrial enzymology: Immobilized enzymes, Covalent and non-covalent, attachments to various substrates. Characteristics of immobilized enzymes. Applications in industry and medicine.
7. Coenzymes: Coenzymes structure and function in metabolism, Redox potential: redox reactions and reactions that generate reducing equivalents, (NADH, NADPH and FADH2), importance of redox potential, calculation of free energy decrease for substrate oxidation, Structure and function of individual complexes of electron transport chain. Complex I, II, III, IV and V.
8. Mechanisms of oxidative phosphorylation: Chemical coupling hypothesis, conformational coupling hypothesis, chemiosmotic hypothesis, mechanism of proton translocation,
9. Photosynthesis: Biological occurrence, various electron donors and acceptors, Photosynthetic pigments, Photosynthetic electron transport chain, and photophosphorylation

Reference Books:

1.Fundamentals of Enzymology, The cell and molecular basis of catalytic proteins - Nicholas C Price and Lewis Stevens, Oxford University Press. (Text Book)

2.Trevor Palmer and Philip Bonner, Enzymes: Biochemistry, Biotechnology, Clinical Chemistry., East-West Press Private Limited, New Delhi, 2nd Edition, 2008.

3.Robert A. Copeland, Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis. Wiley-VCH, Inc. NY, 2nd Edition, 2000

4.Biochemistry, Garrett and Grisham

5.Biochemistry, Berg, Tymoczko and Stryer

MOLECULAR BIOLOGY – I

COURSE NO: BC 452 (3 CREDITS) CORE

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]

Reference Books:

1.Genomes 3 by T. A. Brown

2.Molecular Biology by D. Freifelder, latest edition

3.Molecular Biology of the Gene by J. D. Watson et al., latest edition

4.Molecular Biology of the Cell by Lodish et al., latest edition

5.Recombinant DNA by J. D. Watson, latest edition

6. Reviews and original research articles from journals

STRUCTURAL BIOLOGY

COURSE NO: BC 453 (2 CREDITS) CORE

1. Structure of Biomolecules: Proteins Structures: Introduction and General Overview, Secondary, tertiary and quaternary structure of protein, super secondary structure, Ramachandran plot, protein folding
2. Structural overview of nucleic acids. 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. Primary and secondary structure of RNA: Watson-Crick and Hoogsteen base pairing and Primary and secondary structure DNA: A-DNA, B-DNA, C-DNA conformation, DNA-RNA hybrids, Z-DNA formation.
4. Spectroscopic technique –II: Basic principle of 1. Circular Dichroism Spectroscopy (CD and ORD), 2. ESR, 3. IR 4. Raman and 5. SPR.
5. Techniques used for structural analysis of proteins and nucleic acid: X-ray Crystallography (Symmetry, space group crystal lattices, brag's law in real & reciprocal space), Nuclear magnetic resonance (NMR) and Cryo-electron-microscopy, their limitation and precautions. Mass spectrometry

Reference Books:

1. Protein Structures and Molecular properties by Thomas C Creighton
2. Principles of nucleic acid Structure by Charles R Cantor
3. Physical Biochemistry Principles and Application by David Sheehan
4. Crystallography made crystal clear By Gale Rhodes
5. Outline of Crystallography for Biologists by David Blow

INTERMEDIARY METABOLISM –II

COURSE NO: BC 454 (3 CREDITS) CORE

Protein and Metabolism (20 hours)

1. Dietary protein digestion and absorption of amino acids, intracellular protein degradation, nonoxidative and oxidative deamination, mechanism of transaminase reactions. 3h
2. Fate of ammonia in extra hepatic tissues, glutamine synthesis and transport, alanine cycle, urea cycle reactions and regulation. Biological nitrogen fixation. 3h
3. Fate of the carbon skeleton of amino acids, glucogenic and ketogenic amino acids, relation with TCA cycle and lipogenesis. Amino acid decarboxylation: biogenic amines, polyamines. 5h
4. Biosynthesis of amino acids. Synthesis of essential and non-essential amino acids and regulation of amino acid biosynthesis. Precursor functions of amino acids including Porphyrin metabolism. 7h
5. Inborn errors of amino acid metabolism. 2h

Nucleic acids & Xenobiotic Metabolism (16 hours)

6. Degradation of nucleic acids: deoxyribonucleases and ribonucleases. Nucleotide biosynthesis: de novo purine ribonucleotide biosynthesis and its regulation, purine ribonucleotide biosynthesis from purine bases and ribonucleosides (salvage pathway). Inter conversion of purine ribonucleotides, catabolism of purine bases. 3h
7. Pyrimidine ribonucleotide metabolism: de novo biosynthesis of pyrimidine ribonucleotides and regulation, pyrimidine ribonucleotide biosynthesis from bases and ribonucleotides (salvage pathway). Catabolism of pyrimidine bases. 4h
8. Regulation of purine and pyrimidine nucleotide metabolism; Formation of NDPs and NTPs; Biosynthesis of deoxy-ribonucleotides and its regulation; Inborn errors of nucleotide metabolism; Nucleotide coenzymes. Inborn errors of nucleotide metabolism. 4h
9. Metabolism of 1C units, role of FH4. Methionine and methyl group transfer, Role of vitamin B12 in nucleic acid synthesis. 3h
10. Xenobiotic metabolism: Significance; Phases of xenobiotic metabolism; Types of reactions involved. 2h

Reference Books:

1. *Principles of Biochemistry Authors - Abraham White, Philip Handler and Emil L. Smith*
2. *Lehninger Principles of Biochemistry*
3. *Biochemistry – Author - Lubert Stryer*
4. *Review of Physiological Chemistry Author - Harold Anthony Harper*

BIOCHEMICAL TECHNIQUES-II-LAB COURSE

COURSE NO: BC 455 (5 CREDITS) CORE

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 favourite 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.

COMPONENT 4: 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

CELL BIOLOGY

COURSE NO:
BC 456
(3 CREDITS)
CORE

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)

Reference Books:

1.Molecular Biology of the Cell by Bruce Alberts et al Molecular Cellular Biology by Lodish et al - Relevant reviews and original research papers that would be discussed and distributed in class.

FOUNDATION COURSE

BASIC BIOINFORMATICS AND COMPUTATIONAL BIOLOGY

COURSE NO: FN 214
(3 CREDITS)
FOUNDATION

1. Introduction to Bioinformatics and Computational Biology: History and major developments

2. Introduction to Genes, Genomes, Replication, Transcription and Translation processes in eukaryotes and prokaryotes.

3. Introduction to sequence, structure, pathways, and other biological databases and computational tools

4. Nucleic acid sequence analysis: Sequence alignment, substitution matrices

5. Protein sequence analysis: Sequence alignment, substitution matrices, secondary structure elements, motifs, folds and domains

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, Secondary and tertiary structure prediction

8. Applications to biological problem solving

Reference Books:

1.Krane, D.E. and Raymer, M.L. Fundamental Concepts of Bioinformatics. Pearson Education. 2003. ISBN:978-8177587579

2.James D. Watson *et al.*, Molecular Biology of the Gene, 7th Edition, Pearson Education. ISBN 13: 978- 9332585478

SEMESTER III

BASIC IMMUNOLOGY

COURSE NO: BC 501 (3 CREDITS) CORE

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.

Reference Books:

1.Kuby Immunology; 10th edition; Authors: Owen, Punt, Stranford

2.Wiley: Roitt's Essential Immunology; 13th edition; Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt

3.ELSEVIER: Cellular and Molecular Immunology, 9th Edition; Authors: Abul Abbas, Andrew H. Lichtman, Shiv Pillai

4.Lippincott Williams & Wilkins: Fundamental Immunology By Willium E.Paul; 7th edition

5.Taylor & Francis group: Janeway's Immunobiology; 9th Edition

6.Reviews from journals

MOLECULAR BIOLOGY –II

COURSE NO: BC 502 (3 CREDITS) CORE

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]
5. Exon shuffling, RNA editing and different RNAs and their functions (including siRNA, microRNa and dsRNA, long non-coding RNA), Riboswitch. [3 hours]
6. Translation, ribosome, initiation, elongation and termination steps in protein synthesis, regulation of factors and translation. [4 hours]
7. Secretory Protein biosynthesis, Covalent modifications of proteins (Glycosylation, iodination, methylation, oxidation, phosphorylation etc.) [3 hours]
8. DNAse hypersensitivity, Random and Site-specific mutagenesis, DNA foot printing, finger printing, RFLP, RNA synthesis, polysomes, Protein synthesis in vitro. [3 hours].
9. Methods for studying RNA and transcriptome: northern hybridization; RT-PCR; microarray analysis; SAGE. [3 hours]
10. Studying protein-protein interaction: Yeast two hybrid systems, Co-immunoprecipitation; GST-pull down; FRET and SPR (surface plasmon resonance) [2 hours]

Reference Books:

1.Genomes 3 by T. A. Brown

2.Lewin's Genes by J. E. Krebs et al., latest edition

3.Molecular Biology of the Gene by J. D. Watson et al., latest edition

4.Molecular Biology of the Cell by Lodish et al., latest edition

5.A genetic switch: phage lambda revisited by M. Ptashne

6. Reviews and original research articles from journals

MOLECULAR BIOLOGY-III

COURSE NO: MB 503 (3 CREDITS) CORE

Unit 1: ***Basics of Genomics (4 lectures)***
Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.

Unit 2: ***Genome mapping (5 lectures)***
Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping.

Unit 3: ***Genome sequencing projects (4 lectures)***
Genome sequencing projects for microbes, plants and animals, Human Genome Project, accessing and retrieving genome project information from the web.

Unit 4: ***Comparative Genomics (4 lectures)***
Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.

Unit 5: ***Functional Genomics (5 lectures)***
Transcriptome analysis for identification and functional annotation of gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions.

Unit 6: ***Evolutionary genetics and genomics (6 lectures)***
Genetic drift, drift versus selection, quantitative trait, gene family, chromosome evolution, genome evolution, selfish DNA, competition among levels of organization, species concepts, speciation, phylogeny, coalescent theory, cancer as an evolutionary process.

Unit 7: ***Genome manipulation techniques (5 lectures)***
Transgenic techniques (animal and plant), metabolic engineering, gene knockout, gene knock-down and gene knock-in technologies in various model systems. genome editing (CRISPR-Cas9, ZFN, TALEN etc.)

Unit 8: ***Molecular diagnostics (4 lectures)***
Basic techniques used in molecular diagnostics, future of molecular diagnostics, Fluorescent in-situ hybridization for identification of chromosomal abnormalities.

Reference Books:

1.Principles of Gene Manipulation and Genomics by Primrose.

2.Genetics and Genomics by Hartl

3.Genomes 3 by T. A. Brown

4.Recombinant DNA by J. D. Watson, latest edition

BIOCHEMICAL TECHNIQUES-III-LAB

COURSE NO: BC 504 (5 CREDITS) CORE

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

ENDOCRINE BIOCHEMISTRY

COURSE NO: BC 521 (2 CREDITS) ELECTIVE

1. 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.

2. Digestive processes in various regions of digestive system. Gastrointestinal hormones, their synthesis and function.

3. Structure and function of Insulin like growth factors and their receptors.

Reference Books:

1.Text book if endocrine physiology by James E Griffin and Sergio R Ojeda

2.Endocrinology by Mac Hadley

3.Williams Text book if endocrinology

DEVELOPMENTAL BIOLOGY

COURSE NO: BC 523 (2 CREDITS) ELECTIVE

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.

Reference Books:

1. Developmental Biology by Scott F. Gilbert
2. Developmental Biology: A very Short Introduction by Lewis Wolpert
3. Fundamental Concepts of Developmental Biology by Das N.

SEMESTER – IV

NUTRITIONAL AND CLINICAL BIOCHEMISTRY

COURSE NO: BC 551 (2 CREDITS) CORE

1. An overview of specific aspects of metabolism in different organs and tissues (brain, kidney, liver, skeletal muscle, heart, adipose tissue, blood). 2h
2. General concepts and nutritional requirements of proteins and calories for growth, maintenance and physiologically altered states, nitrogen balance and muscle protein turnover. 2h
3. Disorders of carbohydrates: Diabetes mellitus, non-enzymatic glycation, sorbitol formation, glycohemoglobins, hypoglycemias, galactosemia, various types of glucose tolerance tests, glycogen storage diseases. 2h
4. Disorders of lipids metabolism: Plasma lipoproteins, cholesterol, triglycerides & phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's and Niemann-Pick disease, ketone bodies. 2h
5. Biochemistry of fasting and feeding conditions, interrelations between metabolic pathways, interrelations between liver and peripheral tissues, alcohol metabolism. 2h
6. Malnutrition – Prevention of malnutrition, improvement of diets. Recommended dietary allowances, nutritive value of common foods. Protein-calorie malnutrition. Requirement of proteins and calories under different physiological states- infancy, childhood, adolescence, pregnancy, and lactation. 3h
7. Hypo- and hyperthyroidism and goiter, hypo- and hyper-adrenocorticism, hypo- & hyper- pituitarism, haemoglobinopathies; anemia, thalassemia, sickle cell anemia, jaundice, rheumatoid arthritis; kidney and liver function tests. 3h
8. Scope of clinical biochemistry in diagnosis, collection and preservation of biological fluids (blood, urine & CSF), normal values of important constituents of blood, CSF and urine. Collection preparation, preservation, and handling of clinical samples, quality control, Safety measures in clinical laboratory. 3h
9. Principles of diagnostic enzymology; definition of functional and non-functional plasma enzymes, problems of enzyme assay in clinical biochemistry laboratory; factors affecting enzyme levels in plasma or serum; selection of enzyme tests; enzyme and enzymes pattern in health and diseases with special mention of plasma lipase, amylase, cholinesterase; alkaline and acid phosphates, SGOT, SGPT, LDH & CPK. 3h

Reference Books:

1. Nutritional Elements and Clinical Biochemistry by A. Brewster & Marge

2. Nutritional Biochemistry and Metabolism: With Clinical Applications by Maria C Linder

3. Handbook of Nutritional Biochemistry: Genomics, Metabolomics and Food Supply by Sondre Haugen and Simen Meijer

MOLECULAR BIOLOGY – IV

COURSE NO: MB 576 (3 CREDITS) CORE

Unit 1: ***Basics of Epigenetics (5 lectures)***
Differences between Mendelian and epigenetic inheritance; regulation of gene expression through DNA methylation; regulation of gene expression through chromatin modifications and remodeling.

Unit 2: ***Non-coding RNAs (4 lecture)***
The role of non-coding RNAs in epigenetic regulation.

Unit 3: ***Transgenerational Epigenetics (3 lecture)***
Concepts on how epigenetic modifications are propagated.

Unit 4: ***Effect of environment on epigenetic modification (3 lectures)***
Examples and molecular in-sights taken from lower to higher eukaryotes.

Unit 5*:* ***RNA epigenetics (3 lectures)***
RNA modifications, RNA polymerase pausing and epitranscriptomics

Unit 6: ***Nuclear architecture (4 lectures)***
Large-scale organization of chromosomes, chromosome territories, nuclear compartmentalization, nuclear architecture in genome transactions

Unit 7: ***Epigenetics of genome editing (2 lectures)***

Unit 8: ***Epigenetic gene regulation in development and stem cell biology (2 lectures)***
Discussions of seminal papers.

Unit 9: ***Techniques to study genome-wide mutations and changes in epigenetic landscape (4 lectures)***
ChIP-on-CHIP; ChIP-Seq; DNA methylation detection; NGS; ACGH; CNV.

Unit 10: ***Developing a research proposal in functional genomics and epigenomics (3 lectures)***
Generation of a testable research questions from observations; designing a controlled experiment to testing a hypothesis; presentation of findings of a primary research paper and indicate their significance/limit.

Reference Books:

1. Nuclear organization and function: Cold spring harbour symposia on quantitative biology Volume LXXV (2010). Cold Spring Harbor Laboratory Press
2. Allis D et al., Epigenetics: Cold Spring Harbor Laboratory Press,
3. Armstrong L. Epigenetics: Garland Science publishers
4. Lewin's Genes by J. E. Krebs et al.

ADVANCED MOLECULAR BIOLOGY TECHNIQUES:

COURSE NO: MB 578 (1 CREDIT) CORE

1 Real-time PCR
2 Tagging am eukaryotic gene at its genomic locus
3 Transfection of a plasmid harboring a tagged gene in eukaryotic system
4 Measurement of reporter gene activity
5 Analysis of micro-array data set
6 Analysis of ChIP-Seq data set

COMPREHENSIVE VIVA

COURSE NO: MB 579 (1 CREDIT) CORE

No syllabus.

PROJECT WORK

COURSE NO: BC 553 (12 CREDITS) CORE