

University of Lucknow
Master of Science in Biochemistry Programme

Course Structure: (To be effective from July, 2022)

Code	Nature		Credit	
First Semester				
BCCC-101	Core	Biomolecules: Structure and Function	4	
BCCC-102	Core	Biophysical Techniques	4	
BCCC-103	Core	Enzymology	4	
BCCC-104	Core	Clinical Biochemistry and Physiology	4	
BCCC-105	Core	Laboratory course I: Biological Macromolecules, Clinical Biochemistry	4	
BCVC-101	Val.	Protein Structure	4	
			24	
Second Semester				
BCCC-201	Core	Molecular Cell Biology	4	
BCCC-202	Core	Immunology	4	
BCCC-203	Core	Molecular Biology	4	
BCCC-204	Core	Regulation of Gene Expression	4	
BCCC-205	Core	Intermediary Metabolism	4	
BCCC-206	Core	Laboratory course II: Biophysical techniques, Cell & Microbiology, Immunology	4	
BCVNC-201	Val (NC)	Bioenergetics and Microbiology	0	
			24	
Third Semester				
BCCC-301	Core	Plant Biochemistry	4	
BCCC-302	Core	Genetic Engineering	4	
BCCC-303	Core	Laboratory course III: Plant Biochemistry, Enzymology, Genetic Engineering & Bioinformatics	4	
BCEL-301	Elective/ MOOC	Bioinformatics, Genomics and Proteomics	4	
BCEL-302	Elective	Cancer Biology and Therapeutics		
BCEL-303	Elective	Biostatistics and Computer Application	4	
BCEL-304	Elective	Plant and Animal Biotechnology		
BCIER-301	Interdept.	Environmental Awareness & IPR	4	
			24	
Fourth Semester				
BCMT-401	Core	Dissertation	20	
BCIN-401	Core	Summer Internship*	4	
			24	

* Summer internship will be undertaken during summer vacation that falls between II and III Semester of the programme. Each student will be submitting a report with certificate which will be evaluated in the IV semester, and its credit will also be counted in the IV semester.

COURSE OUTLINE

BCCC-101: Biomolecules: Structure and Function

Course Objective:

1. Extend comprehensive knowledge about structure and properties of biomolecules (monomeric units) of the cell.
2. To teach the students how monomeric molecules of carbohydrate, amino acids, lipid and nucleotides form covalent linkages to form polymers.
3. How these polymers of biomolecules assemble with each other to form supramolecular assemblies having structural and functional role in cell.

Course Outcome: At the end of the course, a student should be able to

1. Know about structure and properties of biomolecules (monomeric units) of the cell.
2. Understand how monomeric molecules of carbohydrate, amino acids, lipid and nucleotides form covalent linkages to form polymers.
3. Understand how these polymers of biomolecules assemble with each other to form supramolecular assemblies having structural and functional role in cell.

Unit I

Carbohydrates: Classification and properties of simple carbohydrates, monosaccharides, disaccharides and polysaccharides. Structural polysaccharides: cellulose and chitin; storage polysaccharides: starch and glycogen; glycosaminoglycans; glycoconjugates: proteoglycans, glycoproteins and glycolipids

Unit II

Fatty Acids and Lipids: Structure, classification and properties of fatty acids, structure and functions of lipids: Triacylglycerides, phosphoglycerides, sphingolipids, cholesterol, steroids, eicosanoids, Lipoproteins

Unit III

Amino acids and proteins: Classification, chemical structure and general properties of amino acids. Standard and non-standard amino acids found in proteins. The peptide bond and its characteristics.

Unit IV

Structure and functions of DNA: Base pairing: Watson-crick, Hoogsteen and Wobble base pairs, The salient features of the Watson-Crick model of B-DNA, The structure and helical parameters of B-DNA, A-DNA, and Z-DNA. Melting temperature (T_m), Forces stabilizing the B-DNA.

Unit V

Structure and functions of RNA: Physicochemical properties of RNA, classification, structure and functions of different types of RNAs (hnRNA, mRNA, rRNA, tRNA, snRNA, snoRNA, antisense RNA telomerase RNA, gRNA, etc.). The clover leaf and L-shaped structures of tRNA.

Suggested Reading:

- Biochemistry by Voet B and Voet JG, Wiley Publishers, USA
- Biochemistry 5th Revised edition by LubertStryer, Jeremy M. Berg, John L. Tymoczko, Macmillan Publishers, USA
- D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; 8th ed. New York

BCCC-102: Biophysical Techniques

Program Objectives and Outcomes

- The course is designed to provide a broad exposure to basic techniques used in Modern Biology research.
- The goal is to impart basic conceptual understanding of principles of these techniques and emphasize biochemical utility of the same.
- Student is expected to have a clear understanding of all analytical techniques such that the barrier to implement the same is abated to a great extent.
- Students will learn to combine previously acquired knowledge of physics and chemistry to understand the biochemical processes in the cell.

UNIT I

Electrochemistry: Ionization of water and its interaction with acids and bases, Buffers and buffering capacity. Determination of pH: theory and instrumentation.

Electrophoresis: Separation of biomolecules on electrophoretic gels: PAGE and agarose gels. Native PAGE, SDS-PAGE, Isoelectric focusing, 2D-PAGE,

UNIT II

Centrifugation: Basic principle of sedimentation, centrifuge and their uses. Rotors. Preparative and analytical centrifugation and their application in Biochemistry.

Chromatography: Partition coefficient, Retention, Resolution, Capacity factor, theoretical plate, van Deemter curve, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography, Hydrophobic interaction chromatography, Paper chromatography, Thin layer chromatography, Fundamentals of high-performance chromatography.

Unit III

Spectroscopic techniques: Basic concepts of molecular bonding and spectroscopy. Energy Levels. Theory of interaction of biomolecules with energy. Principle, instrumentation and applications of atomic absorption and emission spectroscopy.

Concepts and applications of UV-Visible and fluorescence spectrophotometry, EPR, XRD, NMR, MS.

Unit IV

Optical methods for determination of molecular structure: Absorption of polarized light, optical rotatory dispersion, hypochromism, circular dichroism in relation to composition and structure of biomolecules.

UNIT V

Biosensors: Basic techniques, enzyme electrode, organic salt electrode, immunoelectrodes, microbial biosensors.

Tracer techniques: Detection and measurement of isotopes and biological applications.

Suggested Reading:

- Physical Chemistry for the Life Sciences (2nd Revised Edition). Atkins, de Paula. (2015).
- Biophysical Chemistry, Allen Cooper, (2011), Royal Society of Chemistry
- Principles of Physical Biochemistry, K. E. van Holde, C. Johnson, P. S. Ho. (2010) 3rd Edn., Prentice Hall
- C.R. Cantor and P.R. Schimmel (1982) Biophysical Chemistry (Part 1-3), 2nd Edn.

- Joachim Frank (2006) Three-Dimensional Electron Microscopy of Macromolecular Assemblies, Academic Press.
- Physical Chemistry: Principles and Applications in the Biological Sciences. Tinoco, Sauer, Wang, and Puglisi. (2013) Prentice Hall, Inc.

BCCC-103: Enzymology

Course Objectives:

- Enzymes are of key importance in biochemistry as they
- This course aims to acquaint the student with various aspects of enzyme such as classification, properties, enzyme kinetics, mechanisms of enzyme action, regulation of enzyme activity, allosteric enzymes etc.

Course Outcome: This course will enable a student to:

- Have a strong foundation to the understanding of enzymes and biological catalysis
- Compare the kinetic mechanisms of one substrate and bi substrate reactions
- Understand the regulation of enzyme activity enzymes

Unit I

Enzyme definition, nomenclature, classification and characteristics; factors (pH, temperature etc.) affecting the rate of enzyme catalysis; enzyme assay; isolation, purification and characterization of enzymes; enzyme specific activity; units of enzyme activity; isozymes and multiple forms of enzymes.

Unit II

Types of enzyme catalysis: Acid-base catalysis, covalent catalysis, proximity, orientation effect. Strain and distortion theory.

Kinetics of single substrate enzyme-catalysed reactions: Michaelis-Menten initial rate equation based on equilibrium assumption, Briggs-Haldane steady-state approach, V_{max} , K_m and K_{cat} and their significance, methods for the determination of K_m , V_{max} , Derivation of Michaelis-Menten equation for Uni-substrate reactions. Lineweaver-Burk equation and plot.

Unit III

Kinetics of bi-substrate enzyme-catalysed reactions: Cleland representation and nomenclature for multi-substrate reactions, kinetic mechanisms and initial rate equations of random, ordered and ping pong bi-substrate reactions, distinction between different bisubstrate mechanisms using primary and secondary plots.

Enzyme inhibition: competitive, noncompetitive, and uncompetitive inhibition; enzyme kinetics in the presence of inhibitors; derivation of equations for different types of enzyme inhibitors. Determination of K_i ; Suicide inhibitor

Unit IV

Enzyme Regulation: General mechanisms of enzyme regulation, reversible and irreversible covalent modifications of enzymes, feedback inhibition product inhibition; allosteric regulation of enzyme activity: qualitative description of “concerted” & “sequential” models for allosteric enzymes, positive cooperativity, negative cooperativity and half-site reactivity, Hill and Scatchard plots.

Unit V

Techniques for studying the mechanism of enzyme action: Chemical modification of active site groups, Site directed mutagenesis of enzymes.

Physicochemical properties and mechanism of action of two substrate catalysed enzymes: chymotrypsin, lysozyme, hexokinase and alcohol dehydrogenase.

Suggested Reading:

1. Enzymes by Dixon M, Webb EC, 2 ND Ed., Academic Press
2. Enzymes by Palmer, Woodhead Publishing Ltd., UK
3. Biochemistry by Voet B and Voet JG, Wiley Publishers, USA
4. Biochemistry 5th Revised edition by LubertStryer, Jeremy M. Berg, John L. Tymoczko, Macmillan Publishers, USA
5. D.L. Nelson and M.M. Cox Lehninger: Principles of Biochemistry, Publisher: WH Freeman; 8th ed. NewYork

BCCC-104: Clinical Biochemistry and Physiology

Program Objectives and Outcomes

- The knowledge of various body fluids such as blood and urine, their detail composition and alterations under various pathological conditions is of paramount importance. Detailed Physiology of Nerve impulse transmission and muscle contraction is vital to our understanding of these important physiological processes.
- Mechanism of action of various hormones, their physiological roles and pathological disorders along with biochemical roles of vitamins and deficiency disease is important in the modern era.
- The knowledge of various communicable and non-communicable diseases along with lifestyle disorders with their modifiable and non-modifiable risk factors is very important to remain healthy and disease free.

Unit I

Blood: Function and composition: blood groups and Rh factor, plasma proteins and their alteration under pathological condition; mechanism of blood coagulation and clot lysis ; role of leucocytes in defense against pathogens.Urine composition: Alterations under pathological conditions, clinical significance of urine analysis.

Unit II

Nerve impulse transmission: Membrane potential, action potential, transmission of nerve impulse, synthesis, storage and release of neurotransmitters, venoms and nerve poisons.

Muscle contraction: Structural organization of skeletal muscle; skeletal muscle contraction; actin-myosin interactions; regulation of smooth and striated muscle contraction.

Unit III

Hormones: Mechanism of action, metabolic and physiologic role of hormones secreted by pituitary, thyroid, parathyroid, adrenals, pancreas and gonads, disorders due to over and under secretion.Vitamins: Biochemical and physiological roles of vitamins and their deficiency diseases.

Unit IV

Biochemical and clinical aspects of jaundice, atherosclerosis, cancer, diabetes mellitus, Symptoms, diagnosis, treatment and management of Cholera and Dengue.

Unit V

Corona virus pandemic: modes of spread and transmission, mechanism of infection, treatments, vaccination strategies and preventive measures.

Energy metabolism and nutrition: Balanced diet, nutritional aspects of fats, proteins and carbohydrates, protein calorie malnutrition, evaluation of protein quality; starvation and obesity; macrominerals and trace minerals.

Suggested Reading:

- Clinical Biochemistry: Metabolic and Clinical Aspects William J. Marshall, Márta Lapsley et al. Elsevier Health Sciences, 2008
- Textbook of Biochemistry with Clinical Correlation. Thomas M. Devlin. Wiley, 2019
- Bioquímica Clínica. Allan Gaw. Elsevier - Health Sciences Division, 2000
- A Text Book of Biochemistry by West & Todd. Oxford University press.
- Harpers Biochemistry-A Lange Medical edition.

BCVC-101: Protein Structure

Course outcome and objectives:

To have a knowledge base in the structure of proteins. To understand the detailed three dimensional structure of proteins, and the dynamics of their folding and unfolding. To appreciate the relationship between the structure and function of proteins in biological systems.

Unit I

Proteins as the executive molecule in the biological systems, Functional diversity of proteins.

The peptide bond and its properties. Flexibility of polypeptide chains, Ramachandran plot

Hierarchy of three-dimensional structure of proteins.

Primary structure of proteins: Identification of the N- and C-terminal residues, Determination of primary structure of proteins, assignment of disulfide bonds

Unit II

Secondary structure of proteins: α -helices, β -sheets, β -turns, other helical structures.

Tertiary structure of proteins: General structure of globular proteins. Supersecondary structural motifs and domains

Unit III

Quaternary structure of proteins: Symmetry in protein structure, Determination of quaternary structure of proteins: Electron microscopy, succinylation

Protein denaturation, Melting temperature (T_m), Effect of salts on protein structure, Hofmeister series, Salting-in and Salting out, Chaotropic agents

Unit IV

Protein folding: Introduction, thermodynamic and kinetic considerations, the concept of local and global energy minima, Early protein folding experiments on RNase A, Renaturation of post-synthetically modified proteins (insulin), Folding pathways, Levinthal paradox and folding

funnels, The multistage process of protein folding, Folding pathway of bovine pancreatic trypsin inhibitor (BPTI)

Unit V

Folding Accessory Proteins:Proteins disulfide isomerase (PDI), Peptidyl prolyl *cis-trans*isomerase (PPI), Heat shock proteins, Molecular chaperones
Structure and physical properties of representative structural proteins:Keratin, Silk fibroin and Collagen.

Suggested Reading:

- Biochemistry. By Voet D, Voet JG, Wiley Publishers, USA
- Lehninger Principles of Biochemistry. By Nelson DL and Cox MM, Freeman WH and Company
- Biochemistry. By Berg JM, StryerL, Tymoczko J and Gatto G, Macmillan Publishers, USA
- Biochemistry. By Mathews CK, van Holde KE, Appling DR, Anthony-Cahill SJ, Pearson Publishers, USA
- Introduction to Protein Structure. By Branden C and Tooze J, Garland Publishing, New York
- ProteinFolding. By Creighton TE, WH Freeman, Oxford, UK

BCCC-201: Molecular Cell Biology

Course outcome and objectives:

The course aims to an extensive coverage of molecular cell biology and shall enable the student to comprehend problems and latest research in the area. Layering a problem-oriented approach to learning will lead to independent learning of advanced cell biology concepts.

Unit I

Membrane lipids: Physical properties of lipids and their interaction with water to form membranes. Concept of fluidity and factors causing variations in fluidity. Appropriateness of varied lipid geometry for different membrane structures.

Organization of lipids in water: Micelles, liposomes, planar bilayers and dark membranes. Detergents. Solubilization, purification and reconstitution of membrane protein systems. Energetic considerations in membrane organization.

Unit II

Biological membranes: Modification of lipid fluidity by membrane proteins. Arrangement of proteins within lipid bilayers. Hydropathy plots and prediction of membrane spanning domains. Lipid rafts. Membrane asymmetry.

Techniques to study biological membranes: Fluorescence recovery after photobleaching to study membrane fluidity. Use of spin labeling and polarity dependent fluorescence probes to determine membrane state changes.

Unit III

Intracellular vesicular trafficking: Import of proteins into E.R. and processing in the E.R. and Golgi. Mechanism of vesicle formation and fusion. Import of relevant nuclear coded proteins into chloroplasts and mitochondria.

Tracking protein localization: A brief introduction to the study of protein localization using recombinant fluorescent proteins, vesicle fusion using patch clamping and experiments concerning import of proteins into various compartments.

Unit IV

Membrane transport: Channels, transporters and pumps. Active and passive transport. P- and F-type pumps and ABC transporters. Ion channels and electrical properties of membranes. Voltage, ligand and mechanically gated channels. Use of patch clamping to study ion channel activity.

Cell signaling: General principles of signaling switches. Receptor characteristics. Identification and characteristics of receptor proteins. G-proteins and receptor tyrosine kinase mediated signaling. Ca^{2+} flux and its interpretation in cytoplasm, role of Ca^{2+} binding proteins. Signaling pathways dependent on regulated proteolysis.

Molecular probes: Study of intracellular phenomena through the use of specific molecular probes, with emphasis on quantitation of intracellular Ca^{2+} fluxes and pH changes in live cells. Use of FRET to study molecular interactions in live cells.

Unit V

The Cell Cycle: Overview and control. Cyclins, CDKs and Ubiquitin-proteasome dependent control of cell cycle. Checkpoints. Mitosis-meiosis transition and its control.

Apoptosis: The role of programmed cell death in maintaining the social order of cells and in tissue sculpting. Pathways and hallmarks of apoptosis. Role of caspases and Bcl2 family proteins.

Cancer: Transition from normal to cancerous cell growth. Genetic instability and mutations as causative agents. Oncogenes and retroviruses. P₅₃ and associated proteins as tumor suppressors.

Monitoring cell cycle and cell death: A brief introduction to the monitoring of cells passing through the various stages of cell cycle and cell death, using flow cytometry.

Suggested reading:

- Molecular Biology of the Cell-Alberts *et al*
- Molecular Cell Biology-Lodish *et al*
- Cells-Lewin
- Becker's World of Cell-Hardin *et al*
- The Cell: A molecular Approach-Cooper and Hausmann

BCCC-202: Immunology

Course objectives and outcomes:

- To provide a basic knowledge and to appreciate the components of the human immune response that work together to protect the host.
- To understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity.
- To gain an insight into the mechanisms that lead to beneficial immune responses, immune disorders, and immunodeficiencies.
- The basic overview of Immunology strengthens their foundations for a career in Biochemistry.

Unit I

Introduction to Immunology: Innate and Acquired Immune system. Cells, Tissues and Organs of Immune System. Antigen and Antibody. Inflammatory Mediators. Cell Surface Receptors.

Unit II

Host Pathogen Interaction and Intervention Mechanisms I: Antigen processing, presentation and recognition. Mechanisms involving cell mediated and humoral immune response. Mucosal immune system. Complement system and associated deficiencies. Hypersensitivity reactions.

Unit III

Host Pathogen Interaction and Intervention Mechanisms II: Aspects of Microbial Pathogenesis and Host Defense Mechanisms. Mechanisms of Immunological Tolerance. Immunodeficiency diseases – primary and secondary. Autoimmunity and autoimmune disorders.

Unit IV

Host Pathogen Interaction and Intervention Mechanisms III: Basic Transplantation Strategies and Graft Rejection Mechanisms. Mechanisms of Tumor Formation and Evasion Strategies of Host. Vaccination Approaches.

Unit V

Immunology Techniques and Methodologies: Strategies of Antigen and Antibody Purification. Immunoblotting, Agglutination, Precipitation Reactions, Complement Fixation Assays, Fluorescence, Dyes, ELISA, RIA, Microscopy. Concept and Applications of Flow Cytometry.

Suggested Reading:

- Essential Immunology (2005) Roitt I.M. and Delves P.J.
- Essential Immunology (2011) Delves P.J., Martin S. J., Burton D R, Roitt I.M.
- Immunology (2001) Roitt I, Bostoff J. & Male D. 6th edition
- Immunology (2006) Luttmann M, Bratke K., Kupper M., & Myrtek D
- Immunology (2007) Goldsby R.A., Kindt T.J., Osbrne B.A and Kuby J.

BCCC-203: Molecular Biology

Course Objective:

- To teach the dynamic properties of chromatin and its folding.
- To teach topological properties of DNA, reassociation kinetic, transposable elements and genetic code
- To provide students with a deep insight and mechanism of the various cellular processes such as DNA Replication, Transcription and Translation.

Course Outcome: At the end of the course, a student should be able to

- To learn the dynamic properties of chromatin and its folding.
- To learn topological properties of DNA, reassociation kinetic, transposable elements and genetic code
- To understand the mechanism of the various cellular processes such as DNA Replication, Transcription and Translation.

Unit I

DNA topology: DNA supercoiling, linking number, twist and writhe.

Organization of DNA in chromosomes: The dynamic structure of chromatin. Structure of histone core. Histone association with DNA.

DNA melting and reassociation kinetics: Classes of DNA sequences, C_0t curves. Analysis of DNA complexity

Transposable elements: Transposons of bacteria - IS, composite transposons, Tn transposons of *Drosophila*: P and *copia*, Transposons of maize: Ac, Ds, Spm (En), dSpn, Retrotransposons.

Unit II

DNA replication: Modes of DNA replication, components of cellular replisomes and their function (topoisomerase, helicase SSB proteins, primase, DNA polymerase ligase, etc.). Origin of replication in prokaryotes, Eukaryotic origin of replication, Licensing factors and control of eukaryotic replication, Replication of telomeric DNA

Gene stability, DNA damage and DNA repair: DNA repair enzymes, photoreactivation; Nucleotide excision repair; mismatch correction; SOS repair

Unit III

Transcription in prokaryotes: Introduction, promoter architecture, structure of RNA polymerase, role of sigma factor in initiation of transcription, alternative sigma factors and their physiological functions, Termination of transcription, Antitermination in bacteriophage lambda.

Unit IV

Transcription in eukaryotes: Introduction, Transcription factors. Types of RNA polymerase and architecture of their promoters. Initiation of transcription by RNA polymerase I, II, and III. Elongation and termination of transcription; Enhancers and activators

Unit V

Genetic code: Universal genetic code; features of the genetic code, degeneracy of codons; Termination codons; wobble hypothesis; genetic code in mitochondria

Translation: Adaptor role of tRNA, amino acyl tRNA synthetase, A and P sites, initiation codon, formation of 70 S initiation complex, role of initiation factors, peptidyl transferase, translation and elongation factors, role of termination factors. Eukaryotic translation.

Suggested Reading:

1. Molecular biology of the gene by Watson et. Al (5th edition), Pearson Publishers, USA
2. Genes XII by Benjamin Lewin, Oxford University Press
3. Biochemistry by Voet B and Voet JG, Wiley Publishers, USA
4. Biochemistry 5th Revised edition by Lubert Stryer, Jeremy M. Berg, John L. Tymoczko, Macmillan Publishers, USA
5. D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; 8th ed. New York

BCCC-204: Regulation of Gene Expression

Course outcome and objective:

To have a knowledge base in the structure and functions of the genes, and to demonstrate the concept and knowledge of different regulatory strategies in regulation of gene expression in prokaryotes and eukaryotes

Unit I

Basic concept and necessity of regulation of gene expression in prokaryotes and eukaryotes. Principle levels at which regulation is exercised.

Regulation of gene expression in prokaryotes by substitution of σ factor, and by antitermination of transcription

The operon concept: Circuits of regulation of operons. The *lac* operon: repressor control and catabolite repression. The *trp* operon: repressor control and attenuation

Unit II

Maturation of 5' and 3' ends of eukaryotic mRNA: Capping, cleavage and polyadenylation. Function of the cap and the poly A tail of eukaryotic mRNA, and their roles in regulation of gene expression

mRNA splicing and regulation of eukaryotic gene expression: Exons and introns, classification and properties of introns. Autocatalytic splicing, splicing of Group II and Group I introns. Splicing of nuclear pre-mRNA introns. Alternative splicing, mechanism of alternative splicing and its regulation, Role of alternative splicing in sex determination of *Drosophila melanogaster*

Unit III

Activation of transcription factors: Types of transcription factors; mechanisms of activation of transcription factors; Regulation of many genes by a single transcription factor; Regulation of a single gene through different circuits; combinatorial principle of gene expression. Regulation of the *hsp* and *metallothionein* gene

Control of gene expression by DNA methylation, CpG islands

Unit IV

DNA-protein interaction: Physicochemical characteristics of DNA-protein interaction. DNA binding motifs: Homeodomain, Zinc fingers, *b/zip*, *b/HLH*, *b/HLH/zip* motifs

Experimental techniques for study of DNA-protein interactions: Gel retardation assay, DNase I footprinting, Modification protection assay, Modification interference assay

Unit V

Control of gene expression by histone modification: Histone acetylation, deacetylation and methylation. Enzymes associated with these modifications. Chromatin remodeling and chromatin remodeling complexes

Genomic regulatory domains: Introduction to regulation of expression of gene clusters; locus control region (LCR): structure and function LCR of mouse globin gene cluster; Insulators, structure and functions, the insulators of *hsp70* genes of *Drosophila melanogaster*; Genomic imprinting of *Igf-2* and *H-19* genes.

Suggested Reading:

- Lewin's Genes XII. By Krebs JE, Goldstein ES and Kilpatrick ST, Jones & Bartlett Learning, Burlington, MA, USA

- Molecular Biology of the Gene. By Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R, Pearson Publishers, USA
- Molecular Biology of the Cell. By Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P, Garland Science Inc., New York, USA
- Principles of Gene Manipulation: An Introduction to Genetic Engineering. By Old RW and Primrose SB, Blackwell Scientific Publication, Oxford-London-Edinburgh-Boston-Melbourne

BCCC-205: Intermediary Metabolism

Course Objectives: Students will be taught the metabolic pathways of carbohydrate, amino acid, lipid and coenzymes and their regulation. At the end of the course, they will be able to distinguish between different metabolic processes and their impact in metabolism of biomolecules.

Course Outcome: Students should be able to understand the concepts of metabolic processes operating in the biological systems. They shall be able to distinguish between the relevance and implementation of metabolic event and regulation of biochemical mechanisms in the cell. This study will help in enhancing their knowledge towards researches in biochemical and physiological fields.

Unit I

Control of carbohydrate metabolism, Regulation of Glycolysis, Krebs' Cycle, Glycogen Breakdown and Glycogen Synthesis. Homolactic and alcoholic fermentation, hexose-monophosphate pathway. Anaplerotic reactions in metabolism, Krebs-Kornberg pathway.

Unit II

Degradation and biosynthesis of saturated and unsaturated fatty acids. Biosynthesis of lipids: biosynthesis of triglycerides, glycerophospholipids, cerebrosides, ether lipids galactolipids and sulpholipids. Control of lipid metabolism.

Unit III

Biosynthesis of purine and pyrimidine nucleotides. Biosynthesis of coenzymes; Coenzyme A, NAD and NADP, FMN and FAD.

Unit IV

Biosynthesis of amino acids; biosynthesis of α -ketoglutarate, oxaloacetate, pyruvate family amino acids and the control of their synthesis.

Unit V

Transamination, deamination, decarboxylation and urea cycle. Oxidative degradation of glucogenic and ketogenic amino acids.

Suggested Reading:

- Principles of Biochemistry by D.L. Nelson and M.M. Cox Lehninger, Publisher: WH Freeman; recent ed. NewYork.
- Geoffrey L. Zubey, Biochemistry, Fourth Edition: Wm.C. Brown Publishers, 1998
- Biochemistry by Robert Roskoski. W.B. Saunders, Philadelphia, recent ed.
- Enzymes- Dixon and Webb
- Enzymes-Palmer and Bonner

BCVNC-201: Bioenergetics and Microbiology

Objective: Bioenergetics forms the basis of life and provide a reason for the occurrence of biological reaction. Its study is essential for a good understanding of metabolism. Microbial Biochemistry extends the knowledge of pathways to the study of harmful and beneficial microorganisms, usually valid for higher animals.

Course outcomes: The course will enable a student to:

- Understand the basis of life processes like metabolism and biological energy transduction.
- Participate in research and practice of microbiology after post-graduation.

Unit I

Quantitative Bioenergetics: The measurement of driving forces. Gibbs energy and displacement from equilibrium. Oxidation reduction potentials. Ion electrochemical potential differences. Energetic interactions of photons.

Chemiosmotic energy transduction: The chemiosmotic theory. Mitchell's postulates and the morphology of energy transducing organelles. Protonmotive force and its and its relationship to electron transport and ATP synthesis.

Unit II

ATP Synthases: Structure and function of F_1 - F_0 ATP synthase. Mechanism of phosphorylation and uncoupling. Brief introduction to classes of ATPases/synthases and their localization within eukaryotic cells.

Respiratory electron transport chains: Components of the mitochondrial electron transport chain, their sequence and mechanism of electron transfer. Proton translocation by the respiratory electron transport chains

Photosynthetic electron transport and photophosphorylation: Electron transport in bacteria and higher plants – design and relationship to proton translocation. Bacteriorhodopsin and the purple membrane of halobacteria.

Unit III

Virus: Structure, Proteins, Replication, host virus interactions, Zoonotic viruses, Corona virus Pandemic- Modes of transmission, infection, prevention, testing, medication and vaccines.

Bacteria: Classification, morphology, cytology, genetics, nutrition, culture medium for growth, Gram negative and Gram positive bacteria, Gram staining. Structure and function of Peptidoglycan. Biosynthesis of Bacterial cell wall.

Unit IV

Pathogenic microorganisms and their control. Pathogenicity, infection and virulence. Food Spoilage, Food Poisoning and Food Preservation. Prevention of food spoilage.

Antibiotics, Mechanism of infection, drug resistance.

Unit V

Industrial Microbiology: Industrial microbes and their uses in production of food, antibiotics, and hormones. Production of humulin by recombinant DNA technology. Biofertilizers, Genetically modified Microorganisms

Suggested Reading

- Pelczar, M. J., Reid, R. D., & Chan, E. C. (1977). Microbiology (5th ed.). New York: McGraw-Hill.

- Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's microbiology. New York: McGraw-Hill.
- An Industrial Microbiology Waites MJ, Morgn NL, Rockey JS, Higton G, Blackwell Science Ltd, 1st Indian reprint, 2005
- Biochemistry by Voet B and Voet JG, Wiley Publishers, USA
- Biochemistry 5th Revised edition by LubertStryer, Jeremy M. Berg, John L. Tymoczko, Macmillan Publishers, USA
- D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; 8th ed. New York

BCCC-301: Plant Biochemistry

Course objective and outcome: Students will be taught specific aspects of plant biochemistry that are not covered under general biochemistry. The course has been a specialty of the Department of Biochemistry and is designed to give the students comprehensive knowledge of molecular aspects of plant biology. Preparing a strong platform for a research career in the area.

Unit I

Secondary plant products: Biosynthesis of isoprenoids and phenylpropanoids. Alkaloid classification.

The Plant cell wall: Components, structure and integration, Biosynthesis of cell wall, Cell plate formation, Cell expansion, Details of cellulose synthase and expansin action

Mineral nutrient acquisition: Mineral nutrient acquisition from rhizosphere, Mechanisms and strategies, phytochelatins and phytosiderophores

Unit II

Plant defense: Mechanism of plant defense against pathogens, Genetic basis of plant-pathogen interaction, R-Avr gene interaction and isolation of R genes, Hypersensitive response (HR), systemic acquired resistance (SAR) and induced systemic resistance (ISR)

Reactive oxygen and nitrogen species: Generation, scavenging and damage caused by reactive oxygen species (ROS) and reactive nitrogen species (RNS) in plant systems. Roles of ROS and RNS in signaling and plant development

Unit III

Photosynthesis: General Principles and structural background: Energetic principles, system architecture and chlorophyll biosynthesis. Elements of chloroplast-nucleus dialogue and the role of chlorophyll biosynthesis intermediates

Photosynthetic energy transduction: Electron transport, light energy conversion and its control of carbon fixation. Points of cross-talk between electron transport and carbon fixation pathway

Unit IV

Carbon fixation: carbon fixation/assimilation through C₃ (Calvin cycle) and control of metabolite flux through the cycle. Details of rubisco structure, assembly catalysis and regulation. Other regulatory enzymes of Calvin cycle. Light regulation of C₃ cycle

Photorespiration: Photorespiration and carbon concentrating mechanisms (C₄ metabolism and CAM). Role of metabolite transporters in regulating inter-organellar carbon flux.

Unit V

Molecular control of plant photomorphogenesis: Rationale of photoreceptor action and its role in regulating plant responses. Structure, diversity and function of phytochrome, cryptochrome and phototropins.

Photoreceptors: Molecular mechanism of action and signaling mechanism of plant photoreceptors

Suggested Reading:

- Biochemistry and Molecular Biology of Plants-Buchanan *et al*
- Plant Physiology and Biochemistry-Taiz and Zeiger
- Plant Biochemistry-Heldt
- Photosynthesis-Lawlor
- Molecular Life of Plants-Waaland *et al*

BCCC-302: Genetic Engineering

Course Objectives: This course enables the students to:

- Introduce knowledge on basic concepts of recombinant DNA techniques
- Exemplify different types of screening methods for recombinants and their applications
- Implement, organize and design different vectors for gene cloning and expression
- Generating contextual and conditional knowledge of gene function for various applications.

Course Outcomes: After the completion of this course, students will be able to:

- Apply the principles of recombinant DNA techniques
- Analyze the experimental data to select a suitable recombinant for a particular application
- Evaluate selectivity and specificity of vectors for cloning genes and their expressions
- Examine gene function, gene modulation and their effects on improvement of crops and animals.

Unit I

Recombinant DNA technology: historical prospective. DNA Modification and restriction: Restriction Endonuclease: general properties, nomenclature, types (Class I, II and III), and mode of action. DNA methylation.

Enzymes used in recombinant DNA technology (DNA polymerases, DNA ligase, alkaline phosphatases, polynucleotidyl kinases, nucleases etc.).

PCR and variants of PCR (Reverse transcription PCR, nested PCR, Inverse PCR, Degenerate PCR, Touchdown PCR, In-situ PCR, Multiplex PCR, Digital PCR, etc.)

Transcript expression analysis using real time PCR.

Unit II

Plasmid as cloning vector: plasmid types, properties of typical plasmid cloning vector, control of plasmid copy number. Expression vectors

Phage as a cloning vector: Lambda and M13 based vectors.

Hybrid vectors: Cosmids and Phagemids.

Yeast based vectors: YEP, YRP, YCP, YIP, YAC.

Unit III

Cloning: Formation of chimeric DNA using restriction enzyme, homopolymer tailing, synthetic linkers and adaptors. Ligation and transformation

Selection and screening of recombinants: Genetic / nutritional/ phenotypic, immuno-chemical, nucleic acid hybridization, HART/HRT, etc.

Genomic and cDNA libraries: construction approaches

Unit IV

Blotting and Hybridization Techniques: southern, northern, western, eastern, south-western, colony, dot blotting etc.

DNA Probe labeling and detection methods, Autoradiography, non-radioactive probes.

Nucleic acid sequencing: Sanger's and Maxam Gilbert methods, Automated DNA sequencing. Post sequencing analyses. Overview of Next Generation DNA Sequencing (Pyrosequencing, Illumina sequencing etc.).

Unit V

Gene silencing: siRNAs and miRNA Technology, Antisense RNA technology.

Overview on CRISPER-Cas gene editing technology.

Applications of recombinant DNA technology in the field of agriculture, medicine and industry.

Major concerns about Genetically Modified Organisms/Products.

Suggested Reading:

- Genetic engineering by Smita Rastogi and Neelam Pathak, Oxford University Press.
- Nicholl, D.S.T. (1994): An introduction of genetic engineering, Cambridge University Press.
- Christopler, H. (1995) Gene cloning and manipulating Cambridge University Press.
- Gene cloning – T. A. Brown, Blackwell publisher.
- Primrose, S. B., & Twyman, R. M. (2006). Principles of gene manipulation and genomics. Malden, MA: Blackwell Pub.

BCEL-301: Bioinformatics, Genomics and Proteomics

Course Objectives:

- To learn about this relatively newer branch bioinformatics, its definition, objectives and applications.
- To learn about databases and mining tools
- To learn about techniques used in genomics, genome sequencing, annotation.
- To understand about differences between prokaryotic and eukaryotic genomes as well as forward and reverse genetics.
- To impart knowledge about the advances in structural and functional genomics. To understand the use of proteomics techniques

Course Outcomes:At the end of the course, a student should be able to

- Access various global bioinformatics centers such as NCBI, EBI and GenomNet etc.
- Do pairwise and multiple sequence alignments using database mining tools
- Explain the detailed characteristics of prokaryotes and eukaryotes genome
- Apply structural and functional genomics approaches on newly sequenced genome for functional characterization of genes.

Unit I

Introduction to bioinformatics. Different types of data. Databases: nucleic acid database, protein database. Database mining tools for mining of nucleic acid, protein database and other databases.

Unit II

Accessing and retrieving sequence information from databases. Use of sequence alignment tools, BLAST.

Unit III

Introduction to genomics: Structural genomics; genome sequencing projects. Comparative genomics: organization of genome in prokaryotes, eukaryotes and organelles.

Unit IV

Overview of functional genomics: expression profiling, transcriptomics, DNA microarray.

Unit V

Introduction of Proteomics. Branches and applications of proteomics. Techniques of proteomics.

Suggested Reading:

1. 3rd Edition, By S. B. Primrose and R. L. Twyman, Blackwell publishing
2. Bioinformatics and Functional Genomics, 3rd Edition, By Jonathan Pevsner, Wiley-Blackwell
3. Plant Biotechnology by B. D. Singh, Kalyani Publishers

BCEL-302: Cancer Biology and Therapeutics

Course Objectives:

The goal of this course is to introduce students to the field of cancer biology and to train them for learning the mechanisms of cancer development and progression. The course contains learning strategies encompassing cellular and biological approaches for cancer progression and biomedical approaches towards therapy. The ultimate aim is to translate basic findings of research-based study into diagnostics and treatments. In particular, but not limited to, the course will provide a basic aspects of cancer pathogenesis; types of cancer; genomic regulations; mutational and epigenetics changes in tumors; steps of cell cycle regulation & cell cycle, angiogenesis and metastasis; therapeutic aspects from conventional to advance therapies.

Course Outcomes:

The course will stand on its utility towards learning and implementing the aspects towards basic and advance developments in cancer biology. After completing the course the student should have an in depth understanding of the molecular and cellular mechanisms leading to cancer. As well as, they should be able to describe the fundamental mechanistic principles behind cancer diagnosis and prevention, and to understand the principles behind personalized medicine and therapeutics against cancer. Students should be able to perform independent scientific analyses with a research orientation to contribute significantly to academia and/or industry. Students may engage their knowledge in this field for further studies as well skill deployment in research laboratories and industries.

Unit I: Cancer facts and types

Basic understanding of cancers, causes and causative factors; occurrence worldwide and India

Types of cancers – Carcinomas, Sarcomas, Leukaemias and Lymphomas

Genetic and heritable traits of cancer, Sporadic and familial human cancers

Cellular Hallmarks of Cancer

Unit II: Cancer pathogenesis and regulations

Oncogenes and protooncogenes

Transformation of normal cell to cancer, regulation of normal cell growth and differentiation

Cancer cell growth, cell cycle regulation and cell death signalling pathways

Epithelial-mesenchymal transition, Invasion / Intravasation

Angiogenesis and metastasis; role of VEGF, HIF and TGF- β

Unit III: Cancer genetics and regulation

Epigenetic association with cancer, histone modifications and DNA methylation

MicroRNAs and their role in cancer progression

Cancer cell growth signalling pathways viz. WNT/ β -catenin, TP53, MAPKs

Unit IV: Cancer diagnosis and therapies

Cancer diagnosis methods: biopsy, colonoscopy, mammography, Pap test, CT-MRI

Cancer surgeries and radio-therapy

Chemotherapy and anticancer drugs/prototypes from herbal/plant sources

Unit V: Cellular and advance therapies

Basic introduction to immunotherapy, monoclonal antibodies therapy

Cellular engineering methods: Dendritic Cell-based therapy, CAR-T cell therapy

Tumor microenvironment and Cancer Stem Cell therapeutics

Nano-medicine: types of nanoparticles for drug delivery, liposomes structure and drug delivery mechanism

Suggested reading:

1. The Biology of Cancer by Robert A. Weinberg, Garland Publishing Inc.
2. Oxford Textbook of Cancer Biology (Oxford Textbooks in Oncology) by Francesco Pezzella, Mahvash Tavassol and David J. Kerr, OUP Oxford.
3. Molecular Biology of Human Cancers - An Advanced Student's Textbook by Wolfgang Arthur Schulz, Springer Dordrecht.
4. Molecular Biology of the Cell by Bruce Alberts et al. Garland Science Publishing.

BCEL-303: Biostatistics and Computer Applications

Course Objectives and Outcomes:

- Understanding of data and its analysis with the help of computers, Interpretation of data analysis.
- Understanding the basics of computers and computational data analysis which in-turn can be used for interpretation of data analysis.

Unit I

Introductory biostatistics. Experimental design. Sampling techniques. Handling and description of data: tabulation and graphical representation. Measure of central tendency: Mean, Median, Mode, Percentile, Decile and Quartiles.

Unit II

Measure of dispersion: Range, mean deviation, standard deviation, quartile deviation and coefficient of variation.

Unit III

Correlation: types and computation of Karl Pearson's and Spearman's correlation coefficients. Simple linear regression equation and its computation, Regression coefficients. Use of software for statistical data analysis.

Unit- IV

Hypothesis testing. Types of errors. χ^2 (Chi-square) test along with contingency table, Student's t test, f test, and z test. Overview of ANOVA.

Unit- V

Computer: Definition, historical evolution, types and generations, Low-level and High-level languages. Introduction to MS Office: MS Word, MS Excel, MS Power point, Internet/Intranet and its applications.

Suggested Reading:

- Research Methodology and Biostatistics: A comprehensive Guide for Health Care Professionals. By Sharma Suresh.
- Biostatistics and Computer Applications by G.N. Rao, N. K. Tiwari
- Biostatistics: Basic Concepts and Methodology for the Health Sciences. By Wayne W. Oaniel.
- Fundamentals of Biostatistics by Khan and Khanum

BCEL-304: Plant and Animal Biotechnology

Course objectives and Outcomes:

The objectives of this course is to introduce students to the principles, practices and applications of plant biotechnology, plant tissue culture, genetic transformation and transgenics to produce superior varieties. Students will learn the various applications of plant tissue culture and methods of gene transfer, and the production of hybrid varieties of plants in crop improvement.

In addition, students will understand the principles, basic concepts and applications of animal cell culture. The concept of transfer of genes of interest in animal cells and animal cloning along with gene therapy for the treatment of various diseases will be imparted to the students.

Unit I

Cloning in plants: Biology of *Agrobacterium tumefaciens*. Structure of Ti-plasmid, T-DNA and gene transfer mechanisms. Major and minor methods for gene transfer in plants: Gene gun, Electroporation, *In planta* transformation etc. Selection marker and reporter genes
Applications of transgenic plants in phytoremediation, biopesticides, biodegradable plastics, pesticide and herbicide resistance plants, improving horticultural and nutritional value of plants.

Unit II

Plant tissue culture: Historical perspective and general techniques for plant tissue culture. Components of tissue culture media. Culture media preparation, Sterilization techniques.
Explants for Tissue Culture: Shoot tip, axillary buds, leaf discs, cotyledons, inflorescence and floral organs. Callus culture: Initiation and maintenance of callus.
Micropropagation. Protoplast isolation and culture, somatic hybridization, haploid production.

Unit III

Animal cell culture: historical prospective and general techniques for animal cell culture. Cell lines. Cell culture media, maintenance of the culture and cell lines. Cryopreservation. Detection of contamination and laboratory management.

Monolayer culture techniques including dispersion and disruption of tissue, measurement of growth and viability.

Overview of Stem cell technology: types and application.

Unit IV

Cloning in animal cells: SV 40 based vectors, retrovirus based vectors etc.

Genetic engineering of mammalian cells: Mammalian cell lines. Gene transfer techniques in mammalian cells, Gene knockout technology

Somatic cell nuclear transfer and transgenic animals.

Unit-V

Molecular Markers: RFLP maps, RAPD markers, STS, micro satellites, SCAR (sequence characterized amplified regions), SSCP (single strand conformational polymorphism) AFLP, QTL, map based cloning, molecular marker assisted selection.

Suggested Reading:

- Plant tissue culture: Theory and Practice, a revised edition. Bhojwani SS, Razdan MK. An Imprint of Elsevier, First Indian reprint, 2004.
- Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry & molecular biology of plants. Chichester, West Sussex: John Wiley & Sons.
- Brown, T. A. (2006). Gene cloning and DNA analysis: An introduction. Oxford: Blackwell Pub.
- Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Edited by R. Ian Freshney. 6th Ed. Wiley Blackwell, 2010.
- JM Davis. Basic Cell Culture. Oxford University Press. New Delhi, 2008.

BCIER-301: Environmental Awareness & IPR

Course outcome and objective:

- There is urgent need to spread awareness about important environment related issue such as ever increasing air pollution and its effect on animal, plant and human health. Furthermore detailed knowledge of water pollution, its sources waste water management, control and remedial measures in the prevention of spread of various water borne diseases.
- Knowledge about environment problems such as Green house effect, global warming – causes, consequences and remedial measures is of paramount importance to save our planet.
- Basic knowledge of various forms of intellectual property right such as patent, copyrights, geographical indications, industrial design, trademark etc, filing of patent application, infringement of patent rights is very important for MSc. Students of science faculty as intellectual property rights and technological innovation have played an important role in improving the economy of Nations.

Unit I

Air Pollution: Basic Concept, Sources, Suspended Particulate Matter (SPM), Acid Rain, effect of air pollution on plants, animals, human beings and buildings, control of air pollution.

Unit II

Water Pollution: Source, River water pollution, Waste Water Treatment, BOD, and Control of Water Pollution.

Unit III

Soil Pollution: Sources, Soil Erosion, Preservative Measures, Bioremediation.
Xenobiotic Transformation: Phase I and Phase II Reactions.

Unit IV

Greenhouse effect, Global Warming, Chlorofluorocarbons (CFC's), Ozone depletion.

Unit V

IPR: Definition, Basic Concepts, Types, Innovation, Invention, Importance in modern era. Patents, Copyrights, Industrial designs, Trademarks, Geographical indications, Semiconductor integrated circuits, Plant varieties protection act, Trade secret.

Suggested readings:

- Environmental Biochemistry. Neelima Rajvaidya, Dilip Kumar Markandey. APH Publishing, 2005.
- Biochemical Ecotoxicology: Principles and Methods. Francois Gagne. Elsevier, 2014.
- Environmental Biochemistry. Erik Hamilton (Editor). Larsen and Keller Education (21 June 2017)