Master of Science in Biochemistry and Biotechnology

A Two-Year Full Time Programme
(Rules, Regulation and Course Contents)

May 2018

DRAFT OF SYLLABUS FOR CBCS COURSE IN M.Sc. BIOCHEMISTRY AND BIOTECHNOLOGY

Department of Biochemistry
(Faculty of Interdisciplinary and Applied Sciences)
University of Delhi South Campus
Benito Juarez Road
New Delhi-110021

MASTER OF SCIENCE IN BIOCHEMISTRY AND BIOTECHNOLOGY

TWO YEAR FULL TIME PROGRAMME

AFFILIATION

The proposed programme shall be governed by the Department of Biochemistry, Faculty of Interdisciplinary and Applied Sciences, University of Delhi South Campus, New Delhi-110021.

PROGRAMME STRUCTURE

Part I: Semester I

Paper Code	Paper title	Type of Course	Credit
BCCC101	Proteins – Structure, Folding and Engineering	Core	4
BCEC101 BCEC102	Infectious Diseases: Molecular basis, Control and Prevention OR Intermediary Metabolism and Clinical Correlation	Discipline specific elective	4
BCEC103 BCEC104	Life Style Disorders: Cancer and Cardiovascular Diseases OR Advanced Techniques in Biochemistry	Discipline specific elective	4
BCCC102	Seminar on current topics	Core	4
BCCC103	Practicals	Core	8
Total Credits			**24**

Part I : Semester II

Paper Code	Paper title	Type of Course	Credit
BCCC201	Cell Biology	Core	4
BCCC202	Immunology and Immunotechniques	Core	4
BCCC203	Enzymes and their Applications	Core	4
BCCC204	Molecular Biology	Core	4
BCCC205	Practicals	Core	8
Total Credits			**24**

Part II : Semester III

Paper Code	Paper title	Type of Course	Credit
BCCC301	Recombinant DNA Technology and Applications	Core	4
BCCC302	Developmental Biology	Core	4
BCCC303	Proteomics and Metabolomics	Core	4
BCCC304	Presentation : Concepts in Research	Core	4
BCCC305	Practical Skills in Research	Core	8
Total Credits			**24**

Part II : Semester IV

Paper Code	Paper title	Type of Course	Credit
BCCC401	Advanced Techniques in Genomics	Core	4
BCOE401	Basics of Biochemistry	Open Elective	2
BCCC402	Dissertation by Rresearch	Core	18
Total Credits			**24**

(Key: BC – Biochemistry; CC – Core Course; EC – Elective Course; OE – Open Elective)

Grand Total

Total credit of the course	=	96
No. of core papers	=	15
Theory	=	11
Practical	=	2
Project / Dissertation	=	2
No. of discipline specific elective	=	2
No. of open elective	=	1

Semester I

Part I – Semester 1: Core Course

BCCC101

Proteins – Structure, Folding and Engineering

1. Introduction: Importance and Significance of proteins; Functional diversity, Ubiquity, Classes and Dynamism; Structure-function relationship; Key Features.
2. Amino acids as constituents: Ways of representation, Classification, Stereochemistry, Chemical and structural features, Acid/Base properties and their applications.
3. Physico-chemical interactions in biological systems: Covalent & non-covalent interactions, Importance of weak interactions in protein structures.
4. Levels of protein structure: *Primary structure*: Flexibility and conformational restrictions, Characteristics of peptide bond, Ramachandran plot. *Secondary structure*: H-bonding scheme, Diversity in alpha-helices, Helix capping, Beta-stand and sheet, Turns and loops, Importance of loops. *Supersecondary structure*: Domains and motifs. *Tertiary structure*: General properties and characteristics, Structure prediction (modeling). *Quaternary structure*: Concept of subunits and protomers and their association, Importance of quaternary structure; Various examples, Myoglobin and Hemoglobin structures and their relation to cooperativity and allostery.
5. Fibrous and Globular proteins, Structural Features of Membrane proteins
6. Protein Folding and its biotechnological applications: The "protein folding problem" and problems in protein folding; Anfinsen's classical experiment; Folding curves and transitions; Models of protein folding; Assisted protein folding (Chaperones); Misfolding and diseases; Mechanism of sickle-cell disease; Intrinsically disordered proteins; Industrial and medical applications.
7. Protein Engineering: Basic principles; Types and Methods; Strategies in protein engineering (Directed evolution, Comparative design, Rational design); Applications and case studies.
8. Solvent Engineering: Physical basis for protein denaturation/ stability; Preferential binding and preferential hydration models; Various stabilizers and their applications.
9. Sequencing and amino acid composition of peptides and proteins – Conventional and Modern methods and their applications in protein identification, validation, characterization, disease biology, diagnosis and drug discovery.
10. Artificial peptide synthesis and their applications.

Suggested readings

1. C. Branden, T. Tooze. 1999. Introduction to Protein Structure (2nd Ed.), Garland Science, Taylor and Francis Group, New York, USA. ISBN: 978-0-8153-2305-1.
2. T.E. Creighton. 2002. Proteins: Structures and Molecular Properties (3rd Ed.), W.H. Freeman and Company, New York, USA. ISBN 978-0716770305.
3. R. H. Pain. 2000. Mechanisms of Protein Folding, Oxford University Press, Oxford, England. ISBN 978-0716770305.
4. S. Lutz, U. T. Bornscheuer. 2008. Protein Engineering Handbook, Wiley-VCH, Weinheim, Germany. ISBN: 978-3-527-31850-6.
5. V. N. Uversky, A.L. Fink. 2006. Protein Misfolding, Aggregation and Conformational Diseases: Part A: Protein Aggregation and Conformational Diseases (Protein Reviews), Springer, New York, USA. ISBN: 978-1-4419-3851-0.

Part I - Semester I : Discipline Specific Elective

BCEC101

Infectious Diseases: Molecular basis, Control and Prevention

Overview of infectious diseases, infectious agents - Bacteria, Viruses, protozoa and fungi, pathogenicity and virulence; Facultative / obligate intracellular pathogens.

Emerging and re-emerging infectious diseases and pathogens including X-MDR *M. tuberculosis*, MRSA, SARS virus, Bird flu, prions, AIDS, Dengue Hemorrhagic Fever, and Chlamydiae, opportunistic fungal pathogens.

Viral diseases, epidemiology, signs and symptoms, causative agent, history, infection and pathogenesis, Detection, Drugs and inhibitors, Vaccines, molecular mechanisms for AIDS, hepatitis, influenza, dengue, polio, herpes.

Bacterial disease, epidemiology, signs and symptoms, causative agent, history, infection and pathogenicity, Diagnostics, Therapeutics and vaccines. Drug resistance, mechanisms, Multidrug efflux pumps, extended spectrum β-lactamases (ESBL) and implications on public health, molecular mechanisms for Tuberculosis, Typhoid, Cholera.

Parasitic diseases epidemiology, signs and symptoms, causative agents, history, Vectors, life cycle, Host parasite interactions, Diagnostics, Drugs and Inhibitors, Resistance, Vaccine development, molecular mechanisms for Malaria.

Suggested readings

1. Klein's Microbiology (2008) 7th Ed., Prescott, Harley, Willey, J.M., Sherwood, L.M., Woolverton, C.J. Mc Graw Hill International Edition (New York) ISBN: 978-007-126727.
2. Principles and practices of Infectious diseases, 7th edition, Mandell, Douglas and Bennett. S, Volume, 2. Churchill Livingstone Elsevier. ISBN: 978-0-443-06839-3
3. Sherris Medical Microbiology: An Introduction to Infectious Diseases. (2010). Kenneth J. Ryan, C. George Ray, Publisher: McGraw-Hill. ISBN-13: 978-0071604024 ISBN-10: 0071604022
4. Medical Microbiology. (2012). Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller, Elsevier Health Sciences. ISBN: 978-0-323-08692-9.
5. Bacterial Pathogenesis: A molecular approach by Salyers AA and Whitt DD eds. American Society for Microbiology Press, Washington, DC USA. 2002

Part I - Semester I : Discipline Specific Elective

BCEC102

Intermediary Metabolism and Clinical Correlation

1. Overview of metabolism and metabolic reactions, catabolism, anabolism, ATP as energy currency of the cell, reducing power of the cell.
2. Anaerobic production of ATP, Glycolysis, Fermentation, Regulation, Utilization of sugars other than glucose.
3. Gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis, pentose phosphate pathway, glucuronic acid pathway.
4. Aerobic production of ATP, TCA cycle, regulation.
5. Glycogenesis and glycogenolysis, regulation of glycogen metabolism, glycogen storage diseases.
6. Signaling pathways, Hormonal regulation of carbohydrate metabolism, molecular aspects of diseases caused by dysregulation of metabolic pathways
7. Absorption, transport and storage of lipids and TAGs
8. Lipid metabolism and regulation
9. Biosynthesis and degradation of TAGs and phospholipids, fatty acid oxidation, ketone bodies metabolism, ketoacidosis, cholesterol metabolism
10. Molecular mechanism of steroid and lipoprotein metabolism, diseases caused by abnormal metabolic pathways.
11. Role of essential and non-essential amino acids in growth and development. Protein calorie malnutrition - Kwashiorkar and Marasmus
12. Catabolism of amino acids. Glucogenic and ketogenic amino acids. Disorders of amino acids metabolism,
13. Biosynthesis of urea, its regulation and urea cycle disorders.
14. Overview of amino acid synthesis, Biosynthesis of non-essential amino acids and its regulation.
15. Precursor functions of amino acids and its importance
16. De novo synthesis and breakdown of purine and pyrimidinenucleotides, regulation and salvage pathways.
17. Digestion of nucleic acids, Inhibitors of nucleotide metabolism. Disorders of nucleotide metabolism
18. Role of vitamins in metabolic processes
19. Integration of metabolic pathways, tissue specific metabolism (brain, muscle, and liver).

Suggestedreadings

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4 / BRV ISBN: 978-0-470-60152-5.
3. Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4.
4. Harper's Biochemistry (2012) 29th ed., Murray, R.K., Granner, D.K., Mayes and P.A., Rodwell, V.W., Lange Medical Books/McGraw Hill. ISBN:978-0-07-176-576-3.

Part I - Semester I : Discipline Specific Elective

BCEC103

Life Style Disorders: Cancer and Cardiovascular Diseases

1. **Introduction**: Life style associated disorders like obesity, diabetes, chronic obstructive pulmonary diseases (COPD), cancer and cardiovascular diseases (CVDs); Causes, symptoms, complications, diagnosis, intervention and management of disease; Two major killers: Cancer and Cardiovascular diseases

2. **Cancer**: History of cancer; Characteristics of normal and transformed cells; Hallmarks of cancer; Causes and symptoms; Pathophysiology; Stages of cancer; Molecular basis of neoplastic growth and metastasis, Key oncogenic pathways; Proto-oncogenesis and Tumor suppressor genes; Cancer causing mutations; Tumor viruses, Biochemical analysis of cancer and screening methods; Current treatment modalities and their disadvantages, major side effects; Molecular approaches to cancer treatment; Factors affecting prognosis of cancer; Challenges of treatment and disease control strategies. Overview of important techniques related to cancer research.

3. **Cardiovascular diseases**: Definition; The origin of cardiovascular diseases (electrical, structural and circulatory) and types of CVDs; Defining the broad spectrum of ailments; Understanding the underlying factors; Stages of CVDs; Molecular basis of CVDs like hypertension, coronary heart (artery) disease, cerebrovascular disease, cardiomyopathy, cardiac hypertrophy, atherosclerosis, myocardial infarction; Diagnosis and biomarkers; Treatment strategies and management of the condition; Drugs and their discovery; Model systems and animals for CVDs.

4. **Recent Advances**: Introduction to alternative medicines; Case studies; Research status and scope; Ethical, social and regulatory issues.

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Suggested readings

1. Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley &Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
2. Introduction to Human Physiology (2012) 8th edition; Lauralee Sherwood. Brooks/Cole,Cengage Learning. ISBN-13: 978-1133104544 ISBN-10: 1133104541
3. The Cell: A Molecular Approach (2009) 5th ed., Cooper, G.M. and Hausman, R.E., ASMPress& Sunderland (Washington DC), Sinauer Associates, MA, ISBN:978-0-87893-300-6.
4. The World of the cell, 7th edition (2009). Lewis J. Kleinsmith, Jeff Hardin, Gr Wayne M.Becker. ISBN-13: 978-0805393934 ISBN-10: 0805393935.
5. Life style disorders, National health portal of India (https://www.nhp.gov.in/lifestyle-disorder_mtl)
6. https://www.coursehero.com/file/11223115/Cardiovascular-Lecture-Notes/

Part I - Semester I : Discipline Specific Elective

BCEC104

Advanced Techniques in Biochemistry

1. **Biochemical**: Limited proteolysis; Transverse urea gradient gel electrophoresis; Radioisotope and their use in biology, autoradiography, radioactive labeling of biological macromolecules; Equilibrium dialysis, principles and applications; Protein–protein interaction studies: Pull down assays, Immunoprecipitation.

2. **Molecular biology**: DNA and RNA isolation; Northern Blot; Southern Blot; Western Blot; *In situ* hybridization; *In vitro* transcription assay; *In vitro* translation assay; Electrophoretic Mobility Shift Assay; DNA foot printing assay; RNAse protection assay; Chromatin immunoprecipitation; Reporter assays.

3. **Cell biology**: Introduction to mammalian cell culture techniques; Immortalization of cells; Overexpression and Silencing of genes; Generation of transient and stable lines; Cell synchronization techniques; Cell cycle analysis using FACS; Preparation of mouse embryonic fibroblasts; Cytotoxicity assay; Cell viability assays; Cell staining techniques; Cell proliferation assay; Migration assay; Invasion assay; Soft agar assay; Apoptosis assays; Kinase assay; Ubiquitination assay; Protein and mRNA turnover assays; Subcellular fractionation and identification of various fractions.

4. **Computational**: Databases; Genome mining; Virtual cloning; Sequence analysis – alignment, phylogeny, protein primary structure analysis; Protein classification and Structure Prediction, Modeling; Protein structure visualization, superimposition and analysis; Docking and small molecule libraries; Drug design and discovery.

5. **Biophysical**: *Hydrodynamic methods*: Centrifugation, Sedimentation; *Spectroscopic methods:* Absorbance, Fluorescence, Chemiluminescence, Phosphoresence, Circular dichroism, IR, ESR, FRET, Biomolecular fluorescence complementation assay, FRAP (Fluorescence recovery after photobleaching); *Calorimetric methods:* Differential Scanning Calorimetry (DSC) and Isothermal titration Calorimetry (ITC); *Structural methods* : NMR; X-ray crystallography; *Imaging techniques* : Fluorography, PET, MRI; *Microscopy*: Fluorescence microscopy, Confocal microscopy, Electron microscopy, CE Microscopy; *Specialized techniques* : Patch clamp.

Suggested readings

1. D. Sheehan. 2009. Physical Biochemistry: Principles and Applications (2nd Ed.), John Wiley and Sons Ltd, Chichester, England. ISBN: 978-0-470-85603-1.
2. J. Cavanagh, W.J. Fairbrother, A.G. Palmer III, M. Rance, N. J. Skelton. 2007. Protein NMR Spectroscopy: Principles and Practice, Academic Press, San Diego, USA. ISBN: 978-0-12-164491-8.
3. D. W. Mount. 2004. Bioinformatics: Sequence and Genome Analysis, ColdSpringHarbor Laboratory, Plainview, New York, USA. ISBN: 978-0-879-69712-9.
4. M.Zvelebil, J.O. Baum. 2007. Understanding Bioinformatics (1s Ed.), Garland Science, Taylor and Francis Group, New York, USA. ISBN: 978-0815340249.
5. Gale Rhodes. 2006. Crystallography Made Crystal Clear (3rd Ed.), Academic Press, Burlington, USA. ISBN: 978-0-125870733.

Part I - Semester I :Core Course

BCCC102

Seminar on current topics

Students, in this paper, would present open seminars on important and current scientific topics assigned to them by faculties, which would be collectively evaluated by the departmental faculty. The students would survey the available literature on the topics assigned to them, shortlist the relevant material, understand the concepts, techniques and methodologies employed in the research articles, analyze the results obtained and collate the information into a comprehensive presentation. In addition, the students would compile a detailed write-up on the topic assigned and submit as a term paper. As part of the term paper, they would be compiling the relevant bibliography and cite them in the term paper. Students would be educated on the aspects of plagiarism and use of the appropriate softwares to avoid the same.

Part I – Semester I : Core Course

BCCC103

Practicals

1. **Buffers: theory and practice**. **Preparation and storage of buffers and protein stock solutions**: Concept of pH, buffers and pKa; Preparation of buffers in the laboratory over a pH range (2 to 11); Use of pH meters. Handling of buffers and storage concerns.
2. **Protein quantitation and characterization:** Protein handling, storage and concentration; Protein estimation by reagent, dye and non-invasive methods; Concept of extinction coefficient. Spectroscopic characterization of proteins and measurements of their stabilities.
3. ***In silico* protein sequence and structure analysis.** Mining and retrieval of sequences and structures from PDB; Prediction of physical and intrinsic parameters; Sequence alignment; Structure prediction and Homology modeling.
4. **Electrophoresis and Immunoblotting.** Analysis of proteins. Native PAGE and SDS-PAGE for multimeric and disulfide bonded proteins, Visualization of protein bands by Coomassie staining and Silver staining, concept of sensitivity of detection. Determination of molecular weight of a protein using standards, semi-log graph interpretation, Western blot analysis of the proteins using antibodies (immunoblotting).
5. **ELISA**- a qualitative and quantitative method for estimation of analytes, Indirect ELISA and estimation of antibody titres, sandwich ELISA for quantitation of antigen levels in samples. Applications of ELISA.
6. **Agglutination-** Heamagglutination assay and determination of ABO blood group, Latex bead agglutination, applications of agglutination
7. **Bacteria and Bacteriophages** (Lambda and Filamentous): Growing bacterial culture, preparation and sterilization of growth medium, Streaking, inoculation, Growing small-scale Lambda phage and filamentous phage culture, isolating single plaque of filamentous phage by titering serial dilutions, isolating single plaque of Lambda phage by titering serial dilutions.

Semester II

Part I – Semester II : Core Course

BCCC201

Cell Biology

1. The Cell Theory of Life: Historical background, Difference between Prokaryotic and Eukaryotic cells.
2. Sub-Cellular organelles: Isolation and characterization of sub-cellular organelles. Structure and function of sub-cellular organelles.
3. Cytoskeleton and Extracellular matrix: Role in control of cell shape, motility and in intracellular transport. Structure and movement of cilia and flagella. Microtubules, structure and dynamics. Assembly of various extracellular matrix and their role in integrating cells into tissues and cell-cell interactions.
4. Various phases of Cell cycle and regulation. Restriction point of cell cycle and Quiescent cells. Control of cell cycle in yeast and mammalian cells. Role of various cycle-CDK complexes in the transition of various check point of cell cycle. Role of ubiquitin-protein ligase –SCF and APC/C in the control of cell cycle. Cytokinesis.
5. Transport across cell membranes: Understanding membrane transport phenomenon, Passive and active transport, Symport, uniport and antiport.
6. Endocytosis:-Classification of endocytosis, phagocytosis and pinocytosis, clathrin-independent endocytosis, receptor-mediated endocytosis. Mechanism of formation ofclathrin coated pits and vesicles, role of assembly particles in receptor-mediated endocytosis. An overview of exocytosis. Transport of cholesterol and iron in mammalian cells.
7. Endosome-endosome fusion assay. Identification and mechanism of action of various molecular factors (like Rab5, PI-3-Kinase) involved in endosome-endosome fusion.
8. Protein sorting and targeting: Historical background, Protein translocation across ER-membrane, SRP. Modification and quality control of protein in ER: Golgi vesicular traffic, Protein import in mitochondria, peroxisomes, chloroplasts. Signal for Import and Export of Macromolecules from Nucleus
9. Glycosylation in mammalian cells, origin, nature and types of Glycosylation. Role of Glycosylation in protein stability and folding with reference to ER exit.
10. Cellular Signaling: General principles of signaling by cell surface receptors, endocrine, paracrine and autocrine signaling, types of cellular responses induced by signaling molecules, components of intracellular signal-transudation pathways.
11. Short Term Signaling: G-protein coupled receptor system, General mechanism of the activation of effectors molecules associated with G-protein-coupled receptors, G-protein coupled receptors that activate or inhibit adenylate cyclase, G-protein coupled receptors that activate phospholipase C, and G-protein coupled receptors that regulate ion channels.
12. Long Term Signaling: Signaling of growth factors (EGF and Insulin) via activation of receptor tyrosine kinases. Signaling of TGFβ by direct activating Smad proteins. Cytokine signaling via JAK/STAT pathway.
13. Cell Survival and Death Signal: Programmed cell death and role of Caspase protein in apoptosis. Various pro-apoptotic and anti-apoptotic regulators and pathways.

Suggested readings

1. H. Lodish, A. Berk, C.A. Kaiser, M. Kreiger, M. P. Scott, A. Bretscher, H. Ploegh, P. Matsudaria. 2008. Molecular Cell Biology, W.H. Freeman and Company, New York., USA.
2. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P Walter. 2002. Molecular Biology of the Cell, Garland Publishing, Inc. New York. USA.
3. G.M. Cooper. 2000. The Cell: Molecular Approach, ASM Press, Washington, D.C. USA.
4. J.M. Graham and R. Rickwood. 1997. Subcellular Fractionation: A Practical Approach, IRL Press, Oxford University Press. U.K.
5. D.L. Nelson, M.M. Cox. 2008. Lehninger Principles of Biochemistry, W.H. Freeman and Company, New York, USA.
6. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, W.H. Freeman and Company, New York.
7. G. Zubey. 1993. Biochemistry, Wm. C. Brown Publishers, Oxford. U.K.
8. L. Harvey, B. Arnold, Z.S. Lawrence, M. Paul, D. Baltimore, J.E. Darnell. 1999. Molecular Cell Biology, W. H. Freeman & Co, New York, USA.
9. J.G. Siegel, B. W. Agranoff, A. R. Wayne, S.K. Fisher, M.D. Uhler. 1999. Basic Neurochemistry: Molecular, Cellular, and Medical Aspects, Lippincott,Williams& Wilkins, Philadelphia, USA.

Part I – Semester II : Core Course

BCCC202

Immunology and Immunotechniques

1. Historical development of the branch "Immunology". Overview of the immune system. Cells and organs involved in immunity. Hematopoiesis.
2. Antigens, Immunogens, Haptens, Epitopes. Antigen-Antibody interactions. Discovery of immunoglobulins. Structure and function of various classes of immunoglobulins. Development of monoclonal antibodies.
3. Applications of antibodies in diagnostics and routine laboratory assay systems. Agglutination reaction, principles of western blots, radioimmunoassay, ELISA, immunohistochemistry, Flow cytometry. Various immunocytes, their identification/purification.
4. Immunogenetics, Generation of antibody diversity, class switching among constant-region genes.
5. The complement systems, mechanism of complement activation, pathology related to complement proteins.
6. T-cell receptors, maturation, activation and differentiation. B-cell activation and differentiation, B-cell receptor and the immunoglobulin superfamily.
7. Cell mediated immunity, MHC restriction and mechanism of antigen presentation.
8. Generation of B and T cells, Responses, Immunological memory.
9. Properties of cytokines, receptors, effector mechanisms.
10. Concepts of vaccines, whole-organism vaccines, recombinant vaccines, DNA vaccine, synthetic peptide and multivalent sub unit vaccines.
11. Allergy, Cell biology of hypersensitivity reactions.
12. Immunodeficiencies, AIDS.
13. Transplantation immunology.
14. Tumor antigens and cancer immunotherapy.
15. Mechanisms of induction of autoimmunity, treatment of autoimmune diseases.

Suggested readings

1. J. Owen, J. Punt, S. Stranford, (2012) Kuby Immunology (8th Edition), WH Freeman and Company, USA.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. (2012) Biochemistry (7th Edition), W.H. Freeman and Company, USA.
3. D. Male, J. Brostoff, D. Roth, I. Roitt, (2012) Immunology (8th Edition), Saunders, Elsevier, USA.
4. K. Murphy (2011) Janeway'sImmunobiology (8th Edition), Garland Science, USA.
5. A. Abbas, A. Lichtman, S. Pillai, (2014) Cellular and Molecular Immunology (8th Edition), Saunders, Elsevier, USA.

Part I – Semester II : Core Course

BCCC203

Enzymes and their Applications

1. Enzymology: Introduction, General characteristics of enzymes, Activation energy, Coupled reactions, Active site and its importance, Thermodynamics and Equilibrium; Enzyme activity; Specific activity and Units; Isozymes; Ribozymes; Zymogens; Abzymes; Classification and nomenclature of enzymes.
2. Enzyme assays: Types, Continuous and discontinuous assays; Optimization of enzyme assays. Factors influencing catalytic efficiency and the mechanisms employed. Zymography.
3. Enzyme kinetics: Significance; Rapid Equilibrium and Steady State approach, Henry-Michaelis-Menten's and Haldane equations, Significance of K_m, Catalytic efficiency and turnover number; Kinetic perfection. Order of kinetics.
4. Methods of plotting enzyme kinetics data: Lineweaver-Burk, Hanes-Woolf, Woolf-Augustinsson-Hofstee, Eadie-Scatchard; Direct linear plot; Advantages and disadvantages; Integrated form of the Henry-Michaelis-Menten equation; Effect of pH and temperature.
5. Formation of E. S covalent intermediates, transient kinetics, flow techniques (continuous, stopped, quenched), Temp-Jump relaxation experiments.
6. Enzyme Inhibition, Models and types of inhibition; Kinetics and diagnostic plots
7. Multisubstrate enzymes; Multisite and Allosteric enzymes; Models and examples.
8. Mechanism of catalysis of various key enzymes at the molecular level.
9. Regulation and control of enzyme activity: reversible covalent modification, irreversible covalent modification, Half-site reactivity; Bifunctional enzymes.
10. Applied Enzymology: Application of enzymes in industry, diagnostics and medicine, agriculture, research; Immobilized enzymes. Case studies.
11. Synthetic or artificial enzymes and Enzyme engineering; Case studies.
12. Enzyme purification & Chromatography: Gel filtration, ion-exchange, hydrophobic interaction chromatography, affinity chromatography, reversed-phase chromatography; FPLC, HPLC and their applications.

Suggested readings

1. I.H. Segel. 2010. Biochemical Calculations (2nd Ed), John Wiley and Sons, California, USA. ISBN: 978-0-471-77421-1.
2. P. F. Cook, W.W. Cleland. 2007. Enzyme Kinetics and Mechanism, Garland Science Publishing, London, England and New York, USA. ISBN: 978-0815341406.
3. T. Palmer, P. Bonner. 2007. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry (2nd Ed.), Woodhead Publishing House, Chichester, England. ISBN: 978-0-857099921.
4. R. Burgess, M. P. Deutcher. 2009. Guide to Protein Purification, Academic Press, San Diego, USA. ISBN: 978-0-12-374978-9.
5. D. Purich. 2010. Enzyme Kinetics: Catalysis and Control (1st Ed.), Academic Press, San Diego, USA. ISBN: 978-0-123809247.
6. N.C. Price, L. Stevens. 2000. Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins, Oxford University Press, USA. ISBN: 978-0-198-502296.

Part I – Semester II : Core Course

BCCC204

Molecular Biology

The structure of DNA and RNA; Organization of Microbial Genomes, Organization of Eukaryotic Genomes.

Biosynthesis of RNA (Transcription) in prokaryotes: General features of transcription, Discovery and assay of RNA polymerase, Bacterial RNA polymerase, Isolation and characterization of promoters, consensus sequences, up and down mutations. Conserved regions of sigma factors and their role in DNA binding. Elongation, Termination, intrinsic and rho dependent termination, mechanism of action of rho. Anti-termination and gene regulation, Inhibitors of transcription and applications as anti-microbial drugs.

Genetic code: Relationship between genes and proteins, concept of tRNA, triplet nature of genetic code, concept of mRNA, elucidation of genetic code, universality of genetic code, Wobble hypothesis and exceptions, degeneracy of genetic code.

Protein synthesis in prokaryotes and eukaryotes: general features of the process, activation of amino acids. Initiation: initiator tRNAs, RBS, initiation complex, initiation factors. Elongation: Elongation factors, peptide bond formation, translocation. Termination: release factors, ribosome release factors, polycistronic/ monocistronic synthesis, differences between prokaryotes and eukaryotes, coupling of transcription and translation. Role of antibiotics in understanding protein synthesis, Mode of action of various antibiotics in the inhibition of protein synthesis.

Principles of gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, induction of SOS response.

DNA Replication: Semiconservative nature of replication, origin of replication, isolation and mapping of replication origins. Regulation of replication initiation, modes of replication, action of reverse transcriptase, telomerase and their significance. Discovery and properties of DNA polymerases. Mode of action of inhibitors and their therapeutic applications.

DNA Repair: Different types of DNA damages, recognition of DNA damage, types of DNA repair systems including photoreactivation, excision repair, base flipping, mismatch repair, recombination repair, transcription coupled repair and SOS repair. Diseases associated with DNA repair problems.

Eukaryotic Transcription: Characteristics of promoters and enhancer elements. Activators and repressors of transcription, different DNA binding domains. Discovery and properties of eukaryotic RNA polymerases and their mode of action, inhibitors, basal transcription apparatus, initiation, elongation and termination of transcription.

Post-transcriptional processing: Concept of introns and exons, spliceosome machinery, alternative splicing, polyadenylation and capping, processing of rRNA and tRNA. Catalytic roles of RNA; RNA editing.

Regulation of gene expression: Role of chromatin remodeling and gene silencing.

Suggested readings

1. D.L. Nelson, M.M. Cox. (2013). Lehninger Principles of Biochemistry (6th Edition),W.H. Freeman and Company, New York, USA.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. (2012) Biochemistry (7th Edition), W.H. Freeman and Company; New York, USA.
3. B. Lewin, J. Krebs, S.T. Kilpatrick, E.S. Goldstein (2011). Genes X, (10th Volume) Jones and Bartlett Publishers, Sudbury, Massachusetts, USA.
4. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. (2013). Molecular Biology of the Gene (7th edition). Benjamin Cummings, San Francisco, USA.
7. R.F. Weaver (2007). Molecular Biology. (4th edition). McGraw Hill. New York. USA.
8. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter (2015). Molecular Biology of the Cell (6th Edition), Garland Science, New York, USA.
9. H. Lodish, B. Harvey, Arnold, S. Zipursky, S.Lawrence, P. Matsudaira, D. Baltimore, J. Darnell, E. James. (2008). Molecular Cell Biology. (6th Edition) W.H. Freeman and Company, New York, USA.
10. G. M. Cooper and R.E. Hausman. (2013). The Cell: A Molecular Approach (6th Edition), Sinauer Associates, Inc. Massachusetts, USA.
11. R.H. Garrett**,** C.M**.** Grisham**.** 2010**.** Biochemistry, Saunders College Publishers, Texas, USA.

Part I – Semester II : Core Course

BCCC205

Practicals

1. **Animal Tissue Culture**. Introduction to animal tissue culture and various requirements. Growing mammalian cells, trypsinization, plating, cryofreezing and general maintenance of cells. Cell counting using Hemocytometer. Cell viability assay with Trypan blue; Studying the effect of various harsh conditions on cell viability.
2. **Preparation of Transfection Quality Plasmid DNA**: Isolation of plasmids (midi-prep) using commercial columns, analysis of different forms of plasmid and estimation of DNA and total yield.
3. **Transfection and in-cell Visualization of the Ectopically Expressed Protein**. Preparation of DNA Transfection Reagents. Introduction of foreign DNA (plasmids expressing GFP and DSRED) into mammalian cells. Visualization of the GFP and DSRED-tagged protein expression in live cells using fluorescent microscope; Calculation of transfection efficiency. Assessment of localization (nuclear or cytoplasm) and co-localization of the proteins.
4. **Overexpression Analysis**. Harvestation of the transfected cells. Preparation of cell lysate and Western Blot analysis (using ECL) of the over expressed proteins.
5. **Live demonstration of Zebrafish embryogenesis**: Microscopic visualization of early cleavages, sphere stage, shield stage, gastrulation, epiboly and somite formation.
6. **Competent cell preparation and Transformation**. Laboratory preparation of Competent cells (DH 5α). Transformation of circularized plasmid and calculation of transformation efficiency.
7. **Cloning, expression and purification of recombinant proteins**. Amplification of gene by PCR, cloning of gene into expression vector to produce recombinant protein (Isolation of Vector, Restriction digestion, extraction of DNA from gel, Ligation, Transformation). Screening of positive clones by colony PCR and restriction digestion analysis. Expression, localization and purification of recombinant protein.
8. **Measurement of kinetic parameters and inhibition studies.** Determination of K_m, V_{max}, determination of optimal pH, determination of effect of temperature on the stability and activity of the enzyme. Determination of K_i and mode of inhibition.
9. **Bioinformatics Tools.**Pathway predictions, network clustering for protein-protein interactions, docking and virtual screening. A short background to algorithms behind the used computer programs, general concepts of basic scripting.

Part II – Semester III : Core Course

BCCC301

Recombinant DNA Technology and Applications

1. Restriction and Modification systems in *E. coli* and their use in recombinant library construction.
2. Restriction and Modification enzymes and their uses.
3. Basic techniques for RDT including Agarose gel electrophoresis, PAGE, Pulse field electrophoresis.
4. Basic Biology of plasmids including their replication, copy number, Incompatibility of Plasmids, development of Plasmid vectors including screening and selection strategies.
5. Biology of filamentous phages, development of phage and phagemid vectors and their applications.
6. Biology of Bacteriophage lambda, Promoters and control circuits, phage assembly and *in vitro* packaging and development of vectors for different types of Libraries.
7. Vectors for cloning large fragments of DNA, (Cosmid, PAC, YAC and BAC) and strategies for cloning large DNA fragments.
8. Basic DNA sequencing methods, Maxam and Gilbert's chemical and Sanger's chain termination methods, and automated DNA sequencing, Base calling and sequencing accuracy. Introduction to next generation sequencing (NGS).
9. Polymerase chain reaction and its application in research including cloning of PCR amplified fragments, mutagenesis and construction of Libraries. Real time/quantitative PCR.
10. Oligonucleotide synthesis, purification, and its application in cloning, screening of libraries, and mutagenesis. Synthetic gene assembly.
11. Strategies for constructing cDNA libraries and screening using Nucleic acid and antibody probes. Subtractive Libraries, Expression-based strategies for cloning of functional genes, Differential mRNA display.
12. Strategies for constructing Genomic libraries and screening using nucleic acid probes.
13. Understanding of Operons Lac, Trp, Arabinose, Tetracycline and their applications in the development of expression vectors. Use of Tags to aid protein solubility and Purification.
14. Vectors and strategies for expressing heterogeneous proteins in *E. coli*, Yeast, Baculovirus, and mammalian cells.
15. DNA safety guidelines and regulatory aspects.

Suggested readings

1. M.R.Green and J. Sambrook (2012) Molecular cloning, A Laboratory Manual Vol. I-III. (Fourth edition) Cold Spring Harbor Laboratory Press.
2. Fred M. Ausubel*et al.* editors (2017) Current Protocols in Molecular Biology. John Wiley and Sons, Inc.
3. John E. Colligan*et al.* editors (2017) Current Protocols in Protein Science. John Wiley and Sons, Inc.
4. S.B. Primrose and R.M. Twyman. (2006) Principles of Genome Analysis and Genomics. (7th edition) Blackwell Publishing.

5. T.A. Brown. (2016) Gene Cloning and DNA Analysis. (7th Edition). Wiley-Blackwell publishing (Oxford, UK).
6. Articles/Reviews from Methods in Enzymology, Methods in Molecular Biology, Nature Biotechnology, Nature Methods, Nature Protocols, Current Opinion series, Annual Review Series, DBT's Biosafety Guidelines,Current Protocol series and various Journals.

Part II – Semester III : Core Course

BCCC302

Developmental Biology

1. History and basic concepts of developmental processes, mechanisms of specifying cell fate, role of development in evolutionary change.
2. Early events of fertilization, implantation, generation of multicellular embryo, formation of germ layers, patterning of vertebrate body plan.
3. Morphogenesis: Cell adhesion, cleavage and formation of blastula, gastrulation, neural tube formation and cell migration.
4. Molecular events of embryogenesis: Nieuwkoop center, Spemann-Magold organizer theory and mesodermal induction.
5. Model systems
   A. *C. elegans*: Study of cell lineage, cell fate determination, regulation of blastomere identity, anterior-posterior axis formation and organogenesis (vulva formation).
   B. *Drosophila*: Polarily determination of embryo by maternal genes, pattern formation, formation of body segments, homeotic genes and their significance.
   C. *Zebrafish*: Developmental stages, somite formation, mechanisms of pigment patterning in fish skin.
   D. Mouse: Vertebrate development, determining function of genes during development by generation of knockout and knock-in models.
   E. *Arabidopsis*: Development and morphogenesis of plants, role of phytohormones, embryogenesis, flowering, shoot and root development.
6. Cell-cell communication in development: Concepts of induction and competence, epithelial-mesenchymal interactions and developmental signals from extracellular matrix. Brief discussion on role of various signaling pathways during development.
7. Role of stem cells in development: Definition, types and properties of stem cells, adult stem cells and embryonic stem cells, cancer stem cells, stem cell markers, applications of stem cells, advancement in research and ethical issues.
8. Medical implications of developmental biology: Developmental disorders, *in-vitro* fertilization, design of future medicines like gene therapy, therapeutic cloning and regeneration therapy.

Suggested readings

1. S. F. Gilbert. 2008. Developmental Biology (9th Edition), Sinauer Associates, Inc., MA, USA.
2. D.L. Riddle, T. Blumenthal, B.J. Meyer, J.R. Priess. 1997. *C. elegans* II. Cold Spring Harbor Laboratory Press, New York, USA.
3. Worm Book: The Online Review of *C. elegans* Biology. 2005. The *C. elegans* Research Community, Pasadena, USA. (www.wormbook.org)
4. L. Wolpert, R. Beddington, T. Jessell. 2010. Principles of Development (4th Edition), Oxford University Press, New York, USA.
5. H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira. 2003. Molecular Cell Biology, W.H. Freeman, New York, USA.
6. A. Nagy, M. Gertsenstein, K Vintersten, R. Behringer. 2003. Manipulating the mouse embryo: a laboratory manual, Cold spring Harbor Press, New York, USA.

Part II – Semester III : Core Course

BCCC303

Proteomics and Metabolomics

1. Introduction to proteome, proteomics technology, types and kinds of proteomics investigation, overview of systems biology, evolution from protein chemistry to proteomics, importance of proteomics.
2. Abundance-based proteomics: Sample preparation and pre-fractionation steps, Gel-based proteomics - two-dimensional gel electrophoresis (2-DE), evolution of 2DE, two-dimensional fluorescence difference in-gel electrophoresis (DIGE), Staining techniques. applications of 2D and DIGE techniques in biological systems, merits and demerits of gel based proteomics. Two-dimensional gel electrophoresis for biomarker discovery
3. MudPIT, Mass spectrometry (Ionizers, analyzers and detectors) technology and its application in proteomics. Mass spectrometry data analysis – computational/bioinformatics tools.
4. Quantitation proteomics – ICAT, SILAC, iTRAQ, applications of quantitation proteomics. Proteomic profiling for host-pathogen interaction, Understanding proteomics for post-translational modifications.
5. Interaction Proteomics: Protein-Protein Interaction (PPI) and its application in proteomics. Methods to study PPI. yeast two-hybrid, bacterial two-hybrid system, immunoprecipitation, protein microarrays, Nucleic Acid Programmable Protein Array (NAPPA), Label-free nanotechnologies in proteomics, Surface Plasmon Resonance (SPR)
6. Application of proteomics for drug discovery. Biomarkers and drug targets identification. Validation of drug targets and assessment of its toxicology
7. Bioinformatics and proteomics: computational models of proteomics networks.
8. Introduction to metabolomics world. Highthroughput screening systems and utility. Lessons from metabolites, metabolic fingerprinting, and metabolic profiling. Biotechnological potentials of metabolomics.
9. Proteomics approaches in metabolomics. Analysis of differential protein expression, post-translational modifications and protein activity for metabolomics.
10. HPLC and FPLC based approaches in metabolomics. Criteria for the selection of chromatography methods and their importance in metabolomics.
11. Application for cellular metabolomics for metabolic pathway structure. Size of metabolome, metabolite identification, pathway identification and pathway integration. Computational approaches for metabolite identification and translation of results into biological knowledge.
12. Metabolite profiling for infectious disease.
13. Application of metabolite profiling in heart disease. Metabolic signature and metabolite profiling in heart disease.
14. Metabonomics in preclinical pharmaceutical discovery and development. Analytical considerations, and biological aspects and applications.

Suggested readings

1. T. Palzkill. 2002. Proteomics, Kluwer Academic Publishers, New York, USA.
2. E.D. Hoffmann, V. Stroobant. 2007. Mass Spectrometry: Principles and Applications, John Wiley & Sons Ltd. The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England.
3. D. Kambhampati. 2004. Protein Microarray Technology, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany.
4. E. Fung. Methods in Molecular Biology, Volume 264: Protein Arrays, Humana Press Inc., Totowa, NJ.
5. S.G. Villas-Boas. 2007. Metabolome Analysis: An Introduction, Wiley-Blackwell, USA.
6. B. J. Nikolau. 2007. Concepts in Plant Metabolomics, Wurtele, Eve Syrkin, Springer, USA.
7. J. Lindon, J. Nicholson, E. Holmes. 2006. The Handbook of Metabonomics and Metabolomics, Elsevier B.V., Netherlands.

Part II – Semester III : Core Course

BCCC304

Presentation : Concepts in Research

(Students will be allotted laboratories under the supervision of a specific faculty for research work in the beginning of Semester III. The faculty will assign research project to the student. Students in this paper will survey the literature in the field of research assigned to them. This will include gaining knowledge in the general area of research as well as in specific topic assigned to them. They will assimilate the information, collate the findings of the research paper and present seminars on the research topic assigned to them providing background of the research area, the updated knowledge, scope of research and outline potential aims and objectives for subsequent research in the laboratory assigned to them).In addition, this will help them understand the background of the research they will carry out in the subsequent semester.

Part II – Semester III : Core Course

BCCC305

Practical Skills in Research

For this paper, students will get hands on training in several research methods, tools, techniques and instrumentation associated with the research topic assigned to them. They will optimize research protocols necessary for the research project assigned to them. They will study the principle behind various research tools and techniques and collate the materials and methods that will be subsequently used in their research dissertation. There will be continuous evaluation during the course of the semester for their practical skills and they will be required to present the practical skills learnt in the laboratory as an end semester evaluation.

Semester IV

Part II – Semester IV : Core Course

BCCC401

Advanced Techniques in Genomics

1. Mutagenesis: Chemical, random, site-directed and newer methods, and strategies for protein engineering such as DNA shuffling to produce better variants and to study their functions.
2. Regulated vectors for controlled expression of multiple genes (co-expression) to study gene function.
3. Recombinant DNA strategies to study protein interactions. (Phage display, Ribosome Display, Cell Display, Protein fragment complementation).
4. Fundamentals of Whole-Genome Sequencing. Next Generation Sequencing on different platforms, Advanced applications of Next Generation Sequencing.
5. High-throughput genome-wide cloning and protein expression strategies and applications.
6. Antibody gene cloning and engineering, humanization and Human antibodies.
7. Strategies for large-scale expression of recombinant proteins in heterogonous hosts. Purification and downstream processing to produce Therapeutic grade recombinant proteins and monoclonal antibodies and regulatory aspects.
8. Microarray techniques for DNA, Proteins and Antibodies. Global expression profiling.
9. Whole genome and targeted Isothermal DNA amplification and applications.
10. Aptamers and their applications.
11. Cellular Engineering.
12. Micro/si RNA technology and applications in studying gene functions.
13. Gene transfer and expression in plant and applications
14. Gene transfer in mammals and applications

Suggested study material

1. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2017) 5th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC).
2. Erica Golemis and Peter D. Adams (2005) Protein-Protein Interactions: A Molecular Cloning Manual. Cold Spring Harbor Laboratory Press,
3. M.R.Green and J. Sambrook (2012) Molecular cloning, A Laboratory Manual Vol. I-III. (Fourth edition) Cold Spring Harbor Laboratory Press.
4. Fred M. Ausubel*et al.* editors (2017) Current Protocols in Molecular Biology. John Wiley and Sons, Inc.
5. John E. Coligan*et al.* editors (2017) Current Protocols in Protein Science. John Wiley and Sons, Inc.
6. John E. Coligan*et al.* editors (2017) Current Protocols in Immunology. John Wiley and Sons, Inc.
7. S.B. Primrose and R.M. Twyman. (2006) Principles of Genome Analysis and Genomics. (7th edition) Blackwell Publishing.
8. T.A. Brown. (2017) Genomes 4. (IV edition), Garland Science.
9. Carlos F Barbas III, Dennis R BurtonandGregg J Silverman., (2001), Phage Display: A Laboratory Manual, Cold Spring Harbor Laboratory Press.
10. Robert Aitken(Editor) (2009) Antibody Phage Display: Methods and Protocols (Methods in Molecular Biology).
11. Articles/Reviews from Methods in Enzymology, Methods in Molecular Biology, Nature Biotechnology, Nature Methods, Nature Protocols, Current Opinion series, Annual Review Series, DBT's Regulatory Guidelines, Current Protocol series and various Journals.

Part II – Semester IV : Open Elective

BCOE401

Basics of Biochemistry

1. **Carbohydrates and Lipids:**Monosaccharides, disaccharides, Polysaccharides, storage polysaccharides, Building blocks of lipids - fatty acids, glycerol,triacyl glycerol (TAG), Digestion, mobilization and transport of cholesterol and triacylglycerols.

2. **Carbohydrate metabolism:**Glycolysis, pentose phosphate pathway, citric acid cycle, Synthesis of glucose from non-carbohydrate sources, glycogen metabolism, glycogen storage diseases.

3. **Fatty acid metabolism:** β oxidation of fatty acids, regulation of fatty acid oxidation, Fatty acid synthesisand regulation.

4. **Amino acid Metabolism:** Role of essential and non-essential amino acids in growth and development, Catabolism of amino acids, Overview of amino acid synthesis, Protein calorie malnutrition - Kwashiorkar and Marasmus, Disorders of amino acids metabolism.

5. **Nucleotide Metabolism:** *De novo* synthesis and breakdown of purine and pyrimidine nucleotides, regulation and salvage pathways. Disorders of nucleotide metabolism.

6. **Proteins and Enzymes:** Concepts of acids, bases, pH, pKa and buffers, Water & its role in life; Introduction to Protein structures and Protein folding; Structure-function relationship in proteins with Hemoglobin as an example; Enzyme as bio-catalysts: general introduction; Enzyme Kinetics, Inhibition and Regulation; Applications of Proteins and Enzymes.

7. **Vitamins and Hormones:** Different types of vitamins, their diverse biochemical functions and deficiency related diseases.Overview of hormones. Hormone mediated signaling. Mechanism of action of steroid hormones, epinephrine, glucagons and insulin. Role of vitamins and hormones in metabolism; Hormonal disorders; Therapeutic uses of vitamins and hormones.

Suggested readings

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 / ISBN:10:1-4641-0962-1.
2. Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4.
3. Harper's Biochemistry (2012) 29th ed., Murray, R.K., Granner, D.K., Mayes and P.A., Rodwell, V.W., Lange Medical Books/McGraw Hill. ISBN:978-0-07-176-576-3.

Part II – Semester IV : Core Course

BCCC402

Dissertation by Research

Students will carry out the research project assigned to them in semester III and present their research findings in a seminar at the end of semester IV.

The practical skills acquired by the students as well as the concepts and theoretical knowledge gained in semester III in the assigned area will enable them to carry out the research project assigned to them.

There will be a continuous evaluation during the semester for laboratory work and they will present their research findings both as an oral lecture and a written dissertation as an end semester evaluation.