M.Sc. Biochemistry revised syllabus with effect from A.Y. 2021-2022

Core Papers			
Sl. No.	**Subject code**	**Paper title**	**Credits**
1.	BCC 101	Fundamentals of Biomolecules [T]	3
2.	BCC 103	Analytical Biochemistry-I [T]	3
3.	BCC 106	Bioenergetics and metabolism [T]	3
4.	BCC 107	Molecular Biology [T]	3
5.	BCC 108	Laboratory course in Biochemistry-I	4
		a. Fundamentals of Biomolecules [P]	
		b. Analytical Biochemistry-1 [P]	
		c. Molecular Biology [P]	
		d. Field trip/study tour [P]	
Optional Papers			
1.	BCO 110	Immunology and Immunotechniques [T]	3
2.	BCO 111	Biochemistry of Environmental Pollution and Remediation [T]	3
3.	BCO 124	Cell biology [T]	3
4.	BCO 125	Analytical Biochemistry-II	3
5.	BCO 126	Laboratory techniques and Applications of Biochemistry	4
		a. Cell biology [P]	
		b. Immunology and Immunotechniques [P]	
		c. Analytical Biochemistry-II [P]	
		d. Biochemistry of Environmental Pollution and Remediation [P]	

PART -I CORE PAPERS

Programme: M. Sc. (Biochemistry) **Course Code: BCC 101**

Title of the Course: Fundamentals of Biomolecules [T]

Number of Credits: 3 **Effective from AY:** 2021-22

Prerequisites for the course:	Students should have basic knowledge of organic and biomolecules and some of the functional groups and stereochemistry.	
Course Objectives:	1. To develop concepts about structures and functions of different biomolecules. 2. To understand the reactivity of biomolecules and their role in metabolic pathways.	
Course Outcomes:	Students will acquire insights into the structure and functions of various biomolecules and their 3-dimensional arrangements. Students will be able to understand the reactivity of biomolecules which will help them in better understanding of the metabolic pathways.	
Content:	**1. Introduction:** Origin, aim and scope of Biochemistry **Properties of water**: Structure and properties of water, importance of water in biological systems, Ionic product of water. **2. Chemical bonding, Stereochemistry and Reactions:** Properties of covalent bond, non-covalent bonds and their importance in biological systems. Brief revision of configurational nomenclature: R & S; D & L; E & Z; cis & trans and syn & anti nomenclature with respect to biomolecules. Types of biochemical reactions: oxidation-reduction, condensation, rearrangement, cleavage, group-transfer, Resonance bond, electrophilic and nucleophilic substitution reactions. **3. Amino acids and Protein:** Amino acids: Structure, Classification, and physico-chemical properties of amino acids, role of non-protein amino acids,	**3 h** **6 h** **7 h**

	peptides, peptides of physiological significance, peptide bond. Proteins: Structural features of proteins and their biological functions a. Primary Structure: Peptide bond, importance of primary structure. b. Secondary structure: alpha-helix, β - structure, β-helix, super secondary structure. c. Tertiary Structure: Forces stabilizing, unfolding/ refolding d. Quaternary structure – Haemoglobin. **4. Nucleotides and Nucleic acids:** Structure and properties of nucleotides, nucleosides, purine (Adenine, Guanine) and pyrimidine (Cytosine, Thiamine, Uracil) bases. Structural features of nucleic acids (DNA & RNA) and their biological functions. 5. **Carbohydrates:** Structure, stereochemistry, reactions and functions of monosaccharides, disaccharides polysaccharides and complex carbohydrates; amino sugars, proteoglycans and glycoproteins**.** 6. **Lipids**: Classification, structure and function of major lipid subclasses-Triacylglycerols, Phospholipids, Sphingolipids, glycolipids, Lipoproteins, chylomicrons, LDL, HDL and VLDL, steroids, prostaglandins and bile acids, rancidity. Formation of micelles, monolayers, bilayer, liposomes. 7. **Vitamins**: Structure and Classification, water soluble and fat soluble vitamins.	**5 h** **6 h** **6 h** **3 h**
Pedagogy:	Lectures/ tutorials/ assignments/ students' seminars/ interactive learning/ self-study.	

Text Books/ References / Readings	1. Nelson, D. L.; Cox, M. M.; Lehninger Principles of Biochemistry, W.H.Freeman; 2017, 7th Edition. 2. Voet, D.; Voet, J. G.; Pratt, C. W.; Fundamentals of Biochemistry, John Wiley & Sons Inc., 2016, 5th Edition. 3. Berg, J. M.; Stryer, L.; Tymoczko, J. L.; Gatto, G. J.; Biochemistry; W.H Freeman; 2019, 9th Edition 4. Kuchel, P.; Easterbrook-Smith, S.; Gysbers, V.; Guss, J. M.; Hancock, D.; Johnston, J.; Jones, A.; Matthews, J.; Schaum's Outline of Biochemistry, McGraw-Hill Book Co., 2009, 3rd Edition.	

Programme: M. Sc. (Biochemistry) **Course Code: BCC 103**

Title of the Course: Analytical Biochemistry-I

Number of Credits: 3 **Effective from AY:** 2020-21

Prerequisites for the course:	Students should have studied the theory/ instrumentation and application of some of the basic analytical techniques. It is assumed that students have a basic knowledge of fundamentals in biochemistry.	
Course Objectives:	1. Introduction of various bioanalytical techniques for analysis. 2. Evaluate the utility of various analytical techniques as a qualitative and quantitative tool. 3. This course develops concepts in techniques used for routine biochemical work such as chromatography, centrifugation, electrophoresis.	
Course Outcomes:	1. Students should be in a position to differentiate between various analytical techniques based on their theory and sensitivity achieved. 2. Explain the principles of various techniques and apply the knowledge of the techniques for designing various experiments in research and development.	

Content:	1. **Acid, bases and buffers:** concept of pH, eh, acid-base associations, buffers, buffering capacity, mechanism of dissociation of macromolecules, dissociation constants, pKa, pi, solvents (eluotropic series), peroxide values, solubility and affinity constants.	**6 h**
	2. **Centrifugation:** Principle of centrifugation, concepts of RCF, different types of instruments and rotors, preparative, differential and density gradient centrifugation, analytical ultra-centrifugation, determination of molecular weights and other applications, subcellular fractionation.	**5 h**
	3. **Electrophoretic techniques:** Principles of electrophoretic separation. Types of electrophoresis including paper, cellulose, acetate/nitrate and gel. Slab gel, tube, Continuous and discontinuous. Gel electrophoresis - types of gel, Agarose GE, Polyacrylamide gel electrophoresis PAGE, SDS- PAGE, Isoelectric Focusing and ampholytes, 2-D, native, gradient gels, PFGE, DGGE, TGGE. Capillary electrophoresis-instrumentation, sample introduction in CE, types of CE methodology, electrophoretic mobility and electroosmatic mobility, total mobility, efficiency and resolution in CE column. Separation of neutral molecule by MEKC. Staining strategies and procedures: Coomassie Brilliant blue R/G 250, Silver, Fluorescent stains Flamingo, Oriole, SYPRO-Ruby; Stain-free gels.	**8 h**
	4. Separation techniques: Solvent extraction: Basic principle, types of extractions and application. Separations based on a partitioning between phases based on chemical nature and polarity of analyte. Dialysis: Principles, and applications of equilibrium dialysis and ultrafiltration. Artificial membranes, semi-permeable membranes, Donnan membrane equilibrium, and biological	**7 h**

	significance of osmosis and micelles. 5. **Chromatographic techniques:** Basic principles and application of thin-layer, paper chromatography, column chromatography, HPLC, GC, separation matrixes - Ion-exchange, Affinity, Molecular exclusion and Adsorbtion (hydrophobic interaction chromatography, DNA cellulose chromatography, MAK hydroxyl-apatite chromatography). Concept of mobile phases; gradient elution (concave, convex and linear) and stationary phases	**10h**
Pedagogy:	Lectures (online or physical)/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ References / Readings	1. Wilson K, Walker J; Principles and Techniques of Practical Biochemistry; Cambridge University Press; 2010, 7th Edition 2. Christian G. D., Dasgupta P. K , Schug K. A; Analytical Chemistry; John Wiley & Sons; 2013, 7th Edition 3. Norris J. R., Ribbons D.W.; In Methods in Microbiology; Academic Press; 1971,1st Edition. 4. Parakhia M. V., Tomar, R. S., Patel S., Golakiya B. A.: Molecular Biology and Biotechnology: Microbial Methods; New India, 2010. 5. Homes D. J., Peck H; Analytical Biochemistry; Pearson education Limited; 1998. 6. Douglas A. Skoog, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis; Cengage Learning. 2016, 7th Edition.	

Programme: M. Sc. (Biochemistry) **Course Code: BCC 106**
Title of the Course: Bioenergetics and Metabolism [T]
Number of Credits: 3 **Effective from AY:** 2021-22

Prerequisites for the course:	Students should have basic knowledge of biomolecules.	
Course Objectives:	To understand the metabolism of biomolecules and their regulation in living cells.	
Course Outcomes:	Students will be able to understand the pathways associated with the degradation and biosynthesis of major macromolecules in living beings.	
Content:	1. **Bioenergetics** Thermodynamics: laws of thermodynamics, mechanism of exergonic and endergonic reactions, redox potential, high energy compounds, ATP structure and significance. 2. **Oxidative Phosphorylation** Redox enzymes, aerobic electron transport and oxidative phosphorylation, ATP synthase and mechanism. 3. **Carbohydrate metabolism** Regulatory mechanisms, bioenergetics and significance of central pathways of carbohydrate metabolism – Glycolysis Citric acid cycle, Gluconeogenesis from TCA intermediates / amino acids / acetyl-CoA. Pentose phosphate pathway, glyoxalate cycle, glucuronic acid pathway, Utilization of sugars such as lactose, galactose, maltose and of polysaccharides such as starch, glycogen. Biosynthesis of polysaccharides and sugar interconversions. 4. **Lipid metabolism** Oxidation of fatty acids and its energetics: oxidation of saturated and unsaturated (mono and poly unsaturated fatty acids (PUFA), Peroxisomal oxidation of fatty acids (Phytanic acid), Refsum's disease, ketone body formation and their clinical	**4 h** **2 h** **10 h** **8 h**

	significance, diabetic keto acidosis, Biosynthesis of fatty acids and regulation, Biosynthesis of triglycerides, cholesterol and phospholipids. 5. **Nucleotides and Nucleic Acids** Purine and pyrimidine nucleotides: biosynthesis and its regulation. Deoxyribo nucleotides: biosynthesis and regulation. Biosynthesis of nucleotide coenzymes. Catabolism of purine and pyrimidine nucleotides. 6. **Amino acids** General reactions of amino acid metabolism - Transamination, decarboxylation, Oxidative and non-oxidative deamination of amino acids. Special metabolism of methionine, histidine, phenylalanine, tyrosine, tryptophan, lysine, valine, leucine, isoleucine and polyamines. Urea cycle and its regulation. Overview of biosynthethic pathways of amino acids and their regulation; Assimilation of ammonia, biosynthesis of essential and non-essential amino acids, regulation of glutamine synthetase and aspartate family of amino acids.	**5 h** **7 h**
Pedagogy:	Lectures/ tutorials/ assignments/ students' seminars/ interactive learning/ self-study.	
Text Books/ References / Readings	1. Nelson, D. L.; Cox, M. M.; Lehninger Principles of Biochemistry, W.H.Freeman; 2017, 7th Edition. 2. Voet, D.; Voet, J. G.; Pratt, C. W.; Fundamentals of Biochemistry, John Wiley & Sons Inc., 2016, 5th Edition. 3. Berg, J. M.; Stryer, L.; Tymoczko, J. L.; Gatto, G. J.; Biochemistry; W.H Freeman; 2019, 9th Edition 4. Kuchel, P.; Easterbrook-Smith, S.; Gysbers, V.; Guss, J. M.; Hancock, D.; Johnston, J.; Jones, A.; Matthews, J.; Schaum's Outline of Biochemistry, McGraw-Hill Book Co., 2009, 3rd Edition.	

Programme: M. Sc. Biochemistry **Course Code:** BCC 107

Title of the Course: Molecular Biology [T]

Number of Credits: 3 **Effective from AY:** 2021-22

Prerequisites for the course:	Students should have basic knowledge of genetics.	
Course Objective:	To acquaint students on the basic concepts of molecular biology. It explains the structure of nucleic acids, their packaging inside living cells and viruses, damages caused to DNA, the repair mechanisms initiated by the cell, the expression and regulation of genes in prokaryotes and eukaryotes.	
Course Outcome	The student will be able to understand the fundamental concepts of genetics and will gain an understanding on the flow of genetic information in viruses, prokaryotes and eukaryotes.	
Content:	**1. Structure of nucleic acid** Structure of DNA and RNA, Types of DNA based on their structure and their importance in cell (A-DNA, B-DNA, Z-DNA), Types of DNA based on the functionality and their importance in cell (Satellite DNA, Palindrome DNA, Repetitive DNA), Types of RNA (mRNA, antisense mRNA, rRNA, tRNA), Fundamental functions of DNA. **2. Packaging of nucleic material:** Packaging of nucleic material in viruses (icosahedral capsid and helical capsids), Packaging of nucleic acids in prokaryotes (supercoiling, nucleosomes and nonhistone proteins), *Escherichia coli as* a model prokaryotic organism, Packaging of nucleic acids in eukaryotes to form chromosomes (supercoiling, nucleosomes, histones, chromatin and chromosome), Yeast as a model eukaryotic organism, Importance of structural features of chromosome (telomere, centromere and repetitive sequences), Functions of the chromosomes.	**6h** **6h**

	3. DNA damage by mutations, repair and recombination mechanisms Types of mutations (point mutations, frameshift mutations, forward mutations, reverse mutations, suppressor mutations, transitions and transversions), Role of Mutagenic agents (spontaneous and induced mutagenic agents), DNA repair mechanisms/ pathways: (Base excision repair, Mismatch repair, SOS repair, Photoreactivation repair, recombination repair, Mechanisms of Genetic recombination: Homologous and site-specific recombination, Role of synaptonemal complex, lamp brush chromosomes, chi sequences, Rec BCD system, Role of Rec A, Ruv C, Holliday junctions.	**12 h**
	4. **Flow of genetic information and expression of genes in prokaryotes and eukaryotes:** Central Dogma of flow of genetic information, replication of DNA, Transcription of RNA, synthesis and processing (transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA to proteins (reverse transcription). Post transcriptional attenuation, riboswitches, alternate splicing, RNA interference, RNA processing, RNA editing, and polyadenylation, structure and function of different types of RNA, RNA transport. Translation of mRNA to proteins: Structure of Ribosome (eukaryotes and prokaryotes), formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post translational modification of proteins in prokaryotes and Eukaryotes. Control of gene expression at transcription and translation level: regulating the expression of phages, viruses, prokaryotic and	**12 h**

	eukaryotic genes, role of chromatin in gene expression and gene silencing. Role of Recognition sequences or motifs of gene regulatory proteins; Genetic switches and their role in gene expression.	
Pedagogy:	Lectures (online or physical)/ tutorials/laboratory work/ field work/ project work/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. Lodish, H., Berk, A., Matsudaira, P., Kaiser, C.A., Krieger, M., Scott, M.P., Zipursky, L., & Darnell, J.; Molecular cell biology; W.H. Freeman; 2008, 5th Edition. 2. Watson, J. D., Molecular Biology of the Gene; Pearson/Benjamin Cummings; 2013, 7th Edition. 3. Davis, L. G., Dibner, M. D. and Battey, J. F., Basic Methods in Molecular Biology, Elsevier; 1986. 4. Gardner, E. J., Simmons, M. J. and Snustad, D. P. Principles of Genetics, John Wiley & Sons, 1981, 6th Edition.	

Programme: M. Sc. (Biochemistry) **Course Code: BCC 108**

Title of the Course: Laboratory course in Biochemistry-I

Number of Credits: 4 **Effective from AY:** 2021-22

Prerequisites for the course:	Should have studied the theoretical concepts in respective Biochemistry courses.	
Course Objectives	1. This course develops basic understanding and skills of various instruments and techniques in biochemistry, analysing biomolecules, Analytical biochemistry and Molecular biology. 2. The course aims to provide knowledge about the on-going research in various national research institutes and the functioning of industries and industrial processes and also to	

	understand the job prospects in research institutes and industries.	
Course Outcomes	1. Fundamentals of Biomolecules unit of the practical will train the students with skilful handling and estimating biomolecules and other metabolic products. 2. Analytical Biochemistry-I part of this practical will eexplain the principle and working of basic instruments in analytical laboratory that will train the students in handling various instruments in Analysis. 3. Molecular Biology unit of the practical will teach the students techniques involved in genomic DNA isolation and PCR amplification for its use in molecular research. 4. Field trip/study tour unit of this course will help the students to understand the working of industries and research institutions and provide them an insight of the prospects available to them. The students will understand the activities and research being carried out in industries and research institutes which reflects the applications of biochemical principles.	
Content		
	I. Biomolecules 1. Standard curve for glucose by DNSA and quantitative estimation of test sample. 2. Comparison of colorimetric methods for protein estimation – Biuret and Folin-Ciocalteau methods. 3. Estimation of total sugar by anthrone method. 4. Estimation of amino acids (ala, tyr, trp) and protein by direct spectroscopy. 5. Estimation of nucleic acid by direct spectroscopy.	**24 h**
	II. Analytical Biochemistry-I 1. Calibration of pH meter/weighing balance. Preparation of buffers using pH meter and determination of pH of given sample	**24h**

	2. Separation of lipids by thin layer chromatography 3. Column chromatographic separation of organic molecule. 4. Separation of molecules by HPLC. 5. Separation of compounds based on their chemical nature by solvent extraction.	
	III. Molecular Biology **1.** Isolation of genomic DNA of bacterial cells, estimation of quantity and purity of DNA by spectrophotometry, and agarose gel electrophoresis. **2.** PCR amplification of a specific gene using genomic DNA as a template and agarose gel analysis of PCR product to determine amplicon size.	**24 h**
	IV. Field trip/Study tour **1. Visit to Research/Academic Institutes:** E.g., National Centre for Antarctic and Ocean Research [NCAOR], National Institute of Oceanography [NIO], BITS-Pilani, K.K. Birla, Goa campus and ICAR-Central Coastal Agricultural Research Institute (ICAR-CCARI) and such others. 2. **Visits to Industries:** Pharmaceutical industry, Agricultural farming, Food and beverage. **3. Report writing:** Students are supposed to submit report based on above visits highlighting the following points: i. Instrumental facility available and their applications ii. Industrial processes and products iii. Quality checking parameters iv. Ongoing research work. **4. Evaluation:** i. Every student is supposed to present his/ her report before the Committee suggested by the School Council. **ii.** Evaluation will be based on report writings, oral	**24 h**

	presentation and viva.	
Pedagogy:	Lectures/ tutorials/ laboratory work/ field work/ project work/ outreach activities/ viva/ seminars/ assignments/ term papers/ presentations.	
Text Books/ References / Readings:	1. Leksakorn A. and Chaicherdsakul T. Basic Biochemistry laboratory manual. Assumption University Press Inc., Thailand. 2006, 3rd edition. 2. Bettelheim and Landesberg. Laboratory experiments for general, organic and Biochemistry. Harcourt Inc., 2000, 4th edtion. 3. J. Kenkel, Analytical Chemistry for technicians, Lewis publishers, 2002, 3rd Edition. 4. Karson, S., Miller H. Srugi M., Withrow, D.S. Molecular biology techniques: A classroom laboratory manual. Elsevier. 2019, 4th edition. 5. Gakhar S.K, Miglani, M. and Kumar, A. Molecular Biology. A laboratory manual. Wiley. 2019. In addition to above, references given under respective theory courses (BCC 101, BCC 103, BCC 107) may be referred.	

M.Sc. BIOCHEMISTRY PART-I OPTIONAL PAPERS

Programme: M. Sc. (Biochemistry)

Course Code: BCO 110 **Title of the Course:** Immunology and Immunotechniques [T]

Number of Credits: 3

Effective from AY: 2021-22

Prerequisites for the course:	Basic understanding of pathogens, blood cells and human physiology.	
Course Objectives	The objective of the course is to provide an insight into the components of the immune system, their development, their functions and their mechanisms of action and various Immunological techniques.	
Course Outcomes	1. This course will enlighten the students on the importance of immune system in human body to fight pathogens. 2. Students will be able to understand mechanisms of Immunological response. 3. Students will develop an understanding of antigen-antibody interactions and various serological techniques for immunological research.	
Content	1. **Cells and organs of the immune system** 2. **Innate immune response:** Mechanical barriers to infection, Physiological factors contributing to innate immunity, Inflammatory response and Phagocytic system, Complement system. 3. **Adaptive immune response:** Cell-mediated and Humoral immunity- primary and secondary immune response, Major Histocompatibility Complex- Molecular organization of MHC molecules (H-2, HLA), Structure of MHC molecules. Class I MHC-peptide and Class II MHC-Peptide interactions. Antigen presenting cells (APCs), Antigen processing and presentation pathways. **4. Antigens and Antibodies:** Antigens: Chemical complexity and molecular property of	**5h** **5 h** **5h** **4h**

	Antigens, Immunogens, Haptens, Epitopes. Antibodies: Structure and function of various, classes of immunoglobulins, Antigenic determinants on immunoglobulins, monoclonal and polyclonal antibodies and their production by hybridoma technology. 5. **Immunogenetics:** Generation of antibody diversity, class switching among constant-region genes 6. **Immune effector mechanisms** – Cytokines (properties, receptors and functions), Immunological tolerance, Hypersensitivity reactions and Autoimmunity. 7. **Immune system in health and disease**: Immunodeficiencies, AIDS, Transplantation immunology, Concepts of vaccines. 8. **Immunotechniques:** Antigen – antibody reactions: Principles and techniques- *in vitro* precipitation, agglutination, immunofluorescence, immunodiffusion, immunoprecipitation, immunoelectrophoresis, ELISA, RIA, Western blotting, Immunohistochemistry, flow cytometry.	**2h** **5h** **4h** **6h**
Pedagogy:	Lectures (online or physical)/ tutorials/ laboratory work/ viva/ seminars/ term papers/assignments/ presentations/ self-study.	
Text Books/ References / Readings:	1. J. Owen, J. Punt, S. Stranford. J. Patricia. Kuby Immunology, WH Freeman and Company, USA. 2012, 8th Edition. 2. S.J. Martins, D.R. Burton, I.M. Roitt, P.J. Delves. Roitt's Essential Immunology. Wiley Blackwell. 2017, 13th edition. 3. A. Abbas, A. Lichtman, S. Pillai. Cellular and Molecular Immunology. Saunders, Elsevier, USA. 2014, 8th edition. 4. S.C. Parija. Textbook of Microbiology and Immunology. Elsevier. 2012, 2nd edition. 5. F.C. Hay and O.M.R. Westwood. Practical Immunology. Cold spring Harbour. 2002, 4th edition.	

Programme: M. Sc. (Biochemistry) **Course Code:** BCO 111

Title of the Course: Biochemistry of environmental pollution and remediation [T]

Number of Credits: 3 **Effective from AY:** 2021-22

Prerequisites for the course:	It is assumed that the students have a basic knowledge of environment pollutants and biogeochemical cycles (water, O, C, N, S, P).	
Course Objectives:	This course develops concepts in Environmental Pollution (Impact on air, water and soil), role of microorganisms in biogeochemical cycles and bioremediation of pollutants	
Course Outcomes:	Learning of impact of various environmental pollutants on air, water and soil, role of microorganisms in biogeochemical cycles and bioremediation of pollutants and the biochemistry of remediation mechanisms for developing further abatement strategies	
Content:	**1. Environment and Pollutants:** Environment and its component; Atmosphere, soil, aquatic – fresh water, marine systems; biogeochemical cycles. Pollutants: classification, toxicity, synergistic or antagonistic action. Eco-toxicology: concept of permissible limits, ED50 & LD50; acute and chronic exposures; biochemical effects and genotoxicity. Monitoring of pollution using indicator microorganisms, biosensors: genetically modified organisms and enzymes. Significance of dissolved oxygen, BOD, COD. Environment protection regulations, impact assessment and standards. **2. Impact of environmental pollution:** Atmosphere Greenhouse gases and CFCs – sources and effect on the ozone layer; consequences; concept of carbon credit. Atmospheric particulate matter and smog – effect on respiratory system Elements such as asbestos, lead – toxicity and occupational hazards. Soil Xenobiotics, agricultural chemicals, improper waste disposal Hydrocarbons: petroleum and polynuclear aromatics such as naphthalene, benzo-pyrene, solvents, pesticides, lead and other heavy metals –	**14 h** **14 h**

	significance on health. Aquatic/Marine – fresh water, marine systems. Discharge of industrial effluents such as mining, metals, pesticides, textiles, thermal waters, aquaculture, sewage; oil spills – impact on aquatic life and the food chain; consequences on human health **3. Remediation of waste:** Treatment of waste Concepts of Reuse, Recycle, Recovery. Introduction: Waste water/ sewage treatment, Solid waste management, Hospital waste management. Bioremediation: Concept and technologies. Biological systems – plants, bacteria and fungi; microbial consortia. Microbial processes – enzymic transformations, co-metabolism, microbial adhesion, biofilms, production of extracellular polymers and emulsifiers. Removal of metal pollutants through sedimentation, sorption, precipitation, speciation conversion Emerging eco-friendly alternatives for chemical industry – Green chemistry and Green Technology.	**8h**
Pedagogy:	Lectures (online or physical)/ tutorials/laboratory work/ outreach activities/ project work/ viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ References / Readings	1. Manahan S. E; Environmental Chemistry; Lewis Publishers, 2000,7 th edition. 2. Salker A. V; Environmental Chemistry; Narosa Nublishing; 2017, 1st edition 3. De A. k; Environmental Chemistry; New Age International Publishers; 2005, 3 rd Ed 4. Dara, S.S., Mishra D. D; A text book of Environmental Chemistry and Pollution Control; S. Chand Publishers; 2004. 5. Enger E. D., Smith B. E.; Environmental Science: A study of Interrelationships; WCB Publication, McGraw-Hill Higher Education.; 2019, 15 th edition.	

	6. Khopkar S. M., Environmental Pollution Analysis. New Age International Pvt. Ltd.; 2005, 1 st edition. 7. Mitchell R., Cu J. D.; Environmental Microbiology; Wiley-Blackwell Publication; 2009. 8. Moore J. W., Moore, E. A.; Environmental Chemistry; Academic Press; 1976, 1 st edition 9.Maier R., Pepper I., Gerba, C., Gentry T.; Environmental Microbiology; Academic Press; 2008, 2 nd edition	

Programme: M. Sc. (Biochemistry) **Course Code: BCO 124**

Title of the Course: Cell Biology [T] **Number of Credits:** 3

Effective from AY: 2021-22

Prerequisites for the course:	Should have basic knowledge on Prokaryotic and eukaryotic cells.	
Course Objectives	The objective is to offer detailed knowledge about cell biology, various cellular organelles and the cell communication pathways associated with the cellular processes of the cells. The course aims to provide insights of basic cell culture techniques.	
Course Outcomes	1. Students will learn about cell structure, cell division and cell cycle mechanisms, various cellular organelles and their functions. 2. Students will acquire insight into the processes of transport across cell membranes, 3. Students will gain knowledge about the concepts of various cellular communication pathway and their importance. 4. This course will give them understanding of basic Cell culture techniques needed to work in a Biological research laboratory. 5. This course will provide the students with the base for various courses in life science including Cancer biology, Neurochemistry, etc.	

Content	1. **Structural organizations, structure and functions of cellular and sub-cellular organelles:** prokaryotic and eukaryotic cells, Animal and plant cells 2. **Biological membrane structure and function:** Structure and functions of membrane, Transport across cell membrane- Passive and active transport of molecules across biological molecules, membrane pumps. 3. **Cell division and cell cycle:** Mitosis and Meiosis, their regulation 4. **Cellular communication and Cell signalling:** Signal transduction pathway, Signalling molecules and their receptor- G-Protein Coupled Receptors, Receptor Tyrosine Kinases, MAP kinase pathway, JAK-STAT pathway; light signaling in plants, bacterial chemotaxis and quorum sensing Programmed cell death: Apoptosis 5. **Plant tissue culture: techniques and applications-** Introduction to plant tissue culture and various requirements, preparation steps for tissue culture, surface sterilization of plant tissue material, basic procedure for aseptic tissue transfer, tissue culture methodologies; incubation and maintenance of culture; Applications of PTC. 6. **Animal tissue culture: techniques and applications-** Introduction to animal tissue culture and various requirements, Stem cells, typical cell lines, Growing mammalian cells and general maintenance of cells; Application of ATC. 7. **Microbial culture techniques:** *In vitro* culture techniques, nutrient requirements.	**6h** **4h** **4h** **10h** **4h** **4h** **4h**
Pedagogy:	Lectures (online or physical)/ tutorials/ laboratory work/ viva/ seminars/ term papers/assignments/ presentations/ self-study.	
Text Books/ References / Readings:	1. Gerald Karp. Cell and Molecular Biology: Concepts and experiments. John Wiley and sons, Inc. 2015, 8th edition. 2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C.	

	Martin. Molecular cell biology. W.H. Freeman and company, New York. 2016, 8th edition. 3. DeRobertis and Saunders. Cell and Molecular Biology. Saunders College Publishers. 2017, 8th edition. 4. Pranav Kumar and Usha Mina. Pathfinder Academy CSIR-JRF-NET Life Sciences. Pathfinder publications. 2016, 7th edition. 5. Michael Pelczar, Jr, R.D. Reid, E.C.S. Chan. Microbiology. MacGraw-Hill. 2001, 5th edition. 6. R. Ian Freshney. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley-Blackwell. 2016, 7th Edition. 7. Roberta H. Smith. Plant tissue culture: technique and experiments. Academic Press. 2012, 3rd edition.	

Programme: M. Sc. (Biochemistry) **Course Code: BCO 125**

Title of the Course: Analytical Biochemistry-II **Number of Credits:** 3

Effective from AY: 2021-22

Prerequisites for the course:	Students should have studied the theory/ instrumentation and application of some of the basic bio-analytical techniques. It is assumed that students have a basic knowledge of fundamentals in biochemistry and certain basic techniques in routine laboratory analysis.	
Course Objectives:	1. Introduction of various bioanalytical techniques for analysis. 2. Evaluate the utility of various analytical techniques as a qualitative and quantitative tool. 3. Develop concepts in techniques and instruments required for macromolecule structure determination and other techniques such as tracers for metabolic pathways.	
Course Outcomes:	1. Students should be able to differentiate between various analytical techniques based on their theory and sensitivity achieved.	

	2. Students should be in a position to explain the principles of various techniques and apply the knowledge of the techniques for designing various experiments in research and development. 3. Students should be able to choose between various techniques of structure elucidation based on the information desired and interpret the data obtained to a fair level.	
Content:	**1. Optical methods of analysis:** Theory and application of UV-visible spectrophotometry, fluorimetry, atomic absorption spectrophotometry (AAS).	**4 h**
	2. Microscopy: Basic aspects of compound microscope, theory and applications of Light, Dark, Phase-contrast, and Inverted.	**4 h**
	3. Bioimaging and image processing: Principle, application and profile analysis: fluorescence microscopy, epifluorescence, immuno-fluorescence microscopy, and confocal scanning microscopy. Theory, instrumentation and applications of atomic force microscopy (AFM), scanning electron microscopy (SEM), transmission electron microscopy (TEM). Optical tweezers, photography, digital imaging and image processing,	**7 h**
	4. Radioisotopes: Nature of radioactivity and its detection, measurement of radioactivity, Disintegration kinetics, Radio-activity counters – GM Counter, Scintillation Counter, Isotope dilution analysis, Autoradiography, radiorespirometry, Tracer techniques for metabolic pathways. Safety measures in handling radioisotopes.	**7 h**
	5. Spectroscopic techniques for macromolecule structure determination: Principles, application and profile analysis of FTIR, NMR, X-ray diffraction, optical rotatory dispersion, circular dichroism.	**8 h**
	6. Mass Spectrometry: Principle, components, working and applications of mass spectrometer, different types of ionization methods used in mass spectrometer (CI, EI, ESI, FAB), different types of mass analysers used in mass spectrometer (magnetic sector, quadrapole), MALDI-MS, MALDI-TOF-MS, ICP-MS,	**6 h**

	introduction to GCMS, LCMS.	
Pedagogy:	Lectures (online or physical)/ tutorials/ laboratory work/ outreach activities/ project work/ vocational training/ seminars/ term papers/ assignments/ presentations/ self-study etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ References / Readings	1. Wilson, K.; Walker, J.; Principles and Techniques of Practical Biochemistry; Cambridge University Press; 2010, 7th Edition. 2. Christian, G. D.; Dasgupta, P. K.; Schug, K. A.; Analytical Chemistry; John Wiley & Sons; 2013, 7th Edition. 3. Skoog, D. A.; Holler, F. J.; Crouch, S. R. Principles of Instrumental Analysis; Cengage Learning; 2016, 7th Edition. 4. Norris, J. R.; Ribbons, D.W.; Methods in Microbiology; Academic Press; 1971, 1st Edition. 5. Parakhia, M. V.; Tomar, R. S.; Patel, S.; Golakiya, B. A.; Molecular Biology and Biotechnology: Microbial Methods; New India, 2010. 6. Homes, D. J.; Peck, H.; Analytical Biochemistry; Pearson Education Limited; 1998, 3rd Edition. 7. de Hoffmann, E.; Stroobant, V.; Mass Spectrometry: Principles and Applications; John Wiley & Sons Ltd; 2007, 3rd Edition.	

Programme: M. Sc. (Biochemistry) **Course Code: BCO 126**

Title of the Course: Laboratory techniques and Applications of Biochemistry

Number of Credits: 4 **Effective from AY:** 2021-22

Prerequisites for the course:	Should have basic knowledge on various Analytical techniques, Cell biology, Immunotechniques and Biochemistry of environmental pollution and remendiation.	
Course Objectives	The objective of this practical course is to provide hands-on-experience in Cell biology, Immunotechniques, Analytical	

	techniques and analysing environmental samples and pollution.	
Course Outcomes	1. The Cell biology part of the practical will give them understanding and hands-on training of basic Cell culture techniques needed to work in a Biological research laboratory. 2. Immunology and Immunotechniques unit of this practical will train the students with skillful handling of various techniques in Immunological research. 3. Analytical Biochemistry-II part of this practical will explain the principle and working of basic instruments in analytical laboratory that will train the students in handling various instruments in Analysis. 4. Biochemistry of environmental pollution part of this practical will train the students about analysis of environmentally significant water quality parameters and predicting the environmental quality based on observed data.	
Content		
	I. Cell Biology 1. **Microbial culture techniques:** Isolation, identification and characterization and maintenance of bacterial and fungal cells; Cell counting and viability (fungal/bacterial cells). 2. **Animal cell culture techniques:** Isolation, culturing and maintenance of cell lines, Microscopic examination, Cell counting, cytotoxicity and viability testing. 3. **Plant tissue culture techniques:** Surface sterilization of plant material, excision, Aseptic tissue transfer, callus culture and micropropagation.	**24 h**
	II. Immunology and Immunotechniques 1. Agglutination assays: A) Determination of ABO and Rh blood group, B) Latex bead agglutination C) Widal test 2. Immunodiffusion assays:	**24 h**

	A) Single Immunodiffusion B) Double Immunodiffusion 3. VDRL test 4. Rapid tests: A) Malarial antigens Pv/Pf B) Dengue IgM and IgG antibodies C) Hepatitis HBsAg 5. ELISA 6. Immunoelectrophoresis 7. Determination of Immunoglobulins. A) Precipitation of antibodies with (NH4)2 SO4 B) Determination of antibody concentration. C) Separation and visualization of immunoglobulins by SDS-PAGE.	
	III. Analytical Biochemistry – II 1. Visualization of cells by Light and Phase contrast microscopy. 2. UV-Visible spectroscopic studies to demonstrate Beer-Lambert Law, extinction coefficient determination and quantitative analysis. 3. Measurement of fluorescence using Spectrofluorimeter. 4. Demonstration of: GC, IR, NMR, and Mass/MALDI-TOF **5.** Elucidation of structure of cellular metabolites using IR, NMR and Mass profiles.	**24h**
	IV. Biochemistry of environmental pollution and remediation 1. Estimation of Dissolved oxygen (DO) and Biochemical Oxygen Demands (BOD) of given water sample using Winkler method. 2. Estimation of Chemical Oxygen Demands (COD) of water sample and assessment of water quality using observed BOD and COD values. 3. Detection of sewage pollution by screening for indicator organisms such as *E. coli.*	**24 h**

	4. Biotransformation of xenobiotics.	
Pedagogy:	Lectures/ tutorials/ laboratory work/ field work/ project work/ viva/ seminars/ assignments/ term papers.	
Text Books/ References / Readings:	1. Bhatia, S., Naved, T., Sardana, S. Animal tissue culture facilities. IOP publishing ltd., 2019. 2. Sharma G.K., Jagetiya, S., Dashora, R. General Techniques of Plant Tissue Culture. Lulu Press Inc., United States. 2015. 3. Prescott, H. Laboratory exercise in Microbiology. MacGraw-Hill Companies. 2002, 5th edition. 4. Vogel's Text book of Quantitative Inorganic Analysis, Pearson Education, Asia, 2000, 6th Ed. In addition to above, references given under respective theory courses (BCO 124, BCO 110, BCO 125, BCO 111) may be referred.	