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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2023/81/4 Date:26.05.2023

Ref: GU/Acad –PG/BoS -NEP/2022/339/17 dated 18.08.2022

CIRCULAR

In supersession to the above referred Circular, the updated approved Syllabus with revised Course Codes of the **Master of Science in Biochemistry Programme** is enclosed.

The Dean/ Vice-Deans of the School of Chemical Sciences is requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2023.05.26 15:49:29 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

1. The Dean, School of Chemical Sciences, Goa University.
2. The Vice-Deans, School of Chemical Sciences, Goa University.

Copy to:

1. The Chairperson, Board of Studies in Biochemistry PG.
2. The Programme Director, M. Sc. Biochemistry, Goa University.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, PG Examinations, Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Goa University
M.Sc. Biochemistry Part-I revised syllabus (SEM I and SEM II)

SEM I			
Sl. No.	**Subject code**	**Paper title**	**Credits**
1.	CHB-500	Biomolecules and Bioenergetics	4
2.	CHB-501	Analytical Biochemistry-I	4
3.	CHB-502	Molecular Biology	4
4.	CHB-503	Cell and Developmental Biology	4
5.	CHB-521	Practical Course in Biochemistry-I	4
6.	CHB-522	Practical Course in Biochemistry-II	4
SEM II			
1.	CHB-504	Enzymology	4
2.	CHB-505	Analytical Biochemistry-II	4
3.	CHB-506	Immunology and Immunotechniques	4
4.	CHB-507	Industrial Biochemistry	4
5.	CHB-523	Practical Course in Biochemistry-III	4
6.	CHB-524	Plant Biochemistry	4
		SEM-III	
1.	CHB-600	Practical Course in Biochemistry-IV	4
2.	CHB-601	Practical Course in Biochemistry-V	4
3.	CHB-604	Concepts in Genetic Engineering	4
4.	CHB-605	Research methodology, Biostatistics and Bioethics	4
5.	CHB-621	Hormones and Neurochemistry	4
6.	CHB-622	Clinical Microbiology and Food Biochemistry	4
7.	CHB-623	Drug metabolism and Pharmaceutics	4
8.	CHB-624	Bioprospecting and Bioremediation	4
9.	CHI-621	Bioinorganic Chemistry	4
10.	CHA-621	Fundamentals of Crystallography	4
		SEM-IV	
1.	CHB-602	Medical Biochemistry	4
2.	CHB-603	Nanobiotechnology	4
3.	CHB-651	Discipline Specific Dissertation	16

Semster I

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-500 **Title of the Course: Biomolecules and Bioenergetics**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
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. 3. To understand the metabolism of biomolecules and their regulation in living cells.	
Content:		**No of hours**
	1. Introduction to Biomolecules a. Origin, aim and scope of Biochemistry. b. Introduction to various classes of major biomolecules.	1
	2. Structure and properties of water a. Structure and physico-chemical properties of water, Ionic product of water. b. Importance of water in biological systems.	2
	3. Chemical bonding, Stereochemistry and Reactions a. Properties of covalent bond, non-covalent bonds and their importance in biological systems. b. Brief revision of configurational nomenclature: R & S; D & L; E & Z; cis & trans and syn & anti nomenclature with respect to biomolecules. c. Types of biochemical reactions: oxidation-reduction, condensation, rearrangement, addition, elimination, group-transfer, resonance bond, electrophilic and nucleophilic substitution reactions.	7
	4. Structure and Biological functions of biomolecules **a. Amino acids, Peptides and Proteins** i. Amino acids: Structure, Classification, physico-chemical properties of amino acids and role of non-protein amino acids. ii. Peptides: peptides of physiological significance, peptide bond. iii. Proteins: primary (importance of primary structure), secondary (alpha-helix, β – structure, β-helix, super secondary structure), tertiary (stabilizing forces, unfolding/refolding) and quaternary structures (e.g.; Haemoglobin). **b. Nucleotides and Nucleic acids** i. Structure and properties of nucleotides, nucleosides, purine (Adenine, Guanine) and pyrimidine (Cytosine, Thymine, Uracil) bases. ii. Structural features of nucleic acids (DNA & RNA) and their	20

	biological functions. **c. Carbohydrates** i. Structure, stereochemistry, reactions and functions of monosaccharides, disaccharides, polysaccharides. ii. Complex carbohydrates; amino sugars, proteoglycans and glycoproteins. **d. 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.	
	5. **Bioenergetics and Oxidative Phosphorylation** a. Thermodynamics: laws of thermodynamics, mechanism of exergonic and endergonic reactions, redox potential, high energy compounds, ATP structure and significance. b. Aerobic electron transport and oxidative phosphorylation, redox enzymes of ETC, ATP synthase and mechanism.	6
	6. Metabolism of Biomolecules: **a. Carbohydrate metabolism** Regulatory mechanisms, bioenergetics and significance of central pathways of carbohydrate metabolism: Glycolysis, TCA, Pentose phosphate pathway, Entner-Doudoroff pathway, glycolate cycle, Gluconeogenesis, gluconeogenesis from TCA intermediates/ amino acids / acetyl-CoA, glucuronic acid pathway, Utilization of sugars such as lactose, galactose, maltose and of polysaccharides such as starch, glycogen. Biosynthesis of polysaccharides and sugar interconversions. **b. Lipid metabolism** Oxidation of fatty acids and its energetics: oxidation of saturated and unsaturated (mono and polyunsaturated fatty acids (PUFA), Peroxisomal oxidation of fatty acids (Phytanic acid), Refsum's disease, ketone body formation and their clinical significance, diabetic ketoacidosis, Biosynthesis of fatty acids and regulation, Biosynthesis of triglycerides, cholesterol and phospholipids. **c. Amino acid metabolism** 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 biosynthetic pathways of amino acids and their regulation; Assimilation of ammonia, biosynthesis of essential and non-essential amino acids, regulation of glutamine	24

	synthetase and aspartate family of amino acids. **d. Nucleotides and nucleic acids metabolism** Purine and pyrimidine nucleotides: biosynthesis and its regulation. Deoxyribonucleotides: biosynthesis and regulation. Biosynthesis of nucleotide coenzymes. Catabolism of purine and pyrimidine nucleotides.	
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. D. L. Nelson, M. M.Cox , Lehninger Principles of Biochemistry, W.H. Freeman; , 7th Edition,2017. 2. D. Voet, J. G. Voet, C. W.Pratt, Fundamentals of Biochemistry, John Wiley & Sons Inc. 5th Edition,2016. 3. J. MBerg, L Stryer, J. L Tymoczko,G. J Gatto, Biochemistry, W.H Freeman, 9th Edition. 2019. 4. P. Kuchel, S. Easterbrook-Smith, V. Gysbers, J.M. Guss, D.Hancock, J. Johnston, A. Jones, J. Matthews,Schaum's Outline of Biochemistry, McGraw-Hill Book Co,3rd Edition,2009.	
Course Outcomes:	1. Students will be able to classify different biomolecules based on their structure and explain their 3-dimensional arrangement and biological functions. 2. Students will be able to write the metabolic pathways for major macromolecules and recognize the chemical changes occurring at each step based on the functional groups involved. 3. Students will be able to compute the energetics involved in metabolic pathways in terms of number of ATPs and describe the different regulatory mechanisms. 4. Students will be able to relate certain common diseases to the malfunctioning of respective metabolic pathways.	

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-501 **Title of the Course: Analytical Biochemistry-I**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	1. To introduce various bioanalytical techniques for separation and purification of biomolecules. 2. To develop concepts in techniques used for routine biochemical work such as chromatography, spectrophotometry, centrifugation, microscopy, electrophoresis. 3. To evaluate the utility of various analytical techniques as a qualitative and quantitative tool.	
Content:		**No of hours**
	1. General principles of analytical biochemistry a. Selection of valid methods for analysis, Instrumental methods, physiological methods, assessment of analytical methods. b. Quality assurance in analytical biochemistry: quality control and quality assessment, c. Accreditation of laboratories: standard operating procedure and good laboratory practice, sampling for analysis, calibration and graphical representation of data.	4
	2. Acid, bases and buffers a. Units used in quantitative biochemical measurements: molarity, normality, parts per million and percentage by weight/ volume, concept of pH using pH electrode and other ion selective electrodes., Eh, acid-base associations. b. Buffers, buffering capacity, measurement of pH, mechanism of dissociation of macromolecules, dissociation constants, pKa, pI, solvents (eluotropic series), peroxide values, solubility and affinity constants.	10
	3. Colligative Properties a. Definitions, Factors affecting and Physiological Applications of Osmosis. b. Measurement of osmotic pressure, Osmoregulation, Adsorption, Colloids, Surface Tension and Viscosity. c. Numerical Problems based on above concepts.	4
	4. **Centrifugation:** a. Principle of centrifugation, concepts of RCF, different types of instruments and rotors. b. Preparative, differential and density gradient centrifugation, analytical ultra-centrifugation. c. Determination of molecular weights and other applications, subcellular fractionation.	8
	5. Electrophoretic techniques: a. Principles of electrophoretic separation, Types of electrophoresis including paper, cellulose, acetate/nitrate and gel (introduction to concepts of slab gel, tube,	10

	continuous and discontinuous, etc). b. 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. c. Capillary electrophoresis - instrumentation, sample introduction in CE, types of CE, electrophoretic mobility and electroosmotic mobility, total mobility, efficiency and resolution in CE column. d. Separation of neutral molecules by MEKC. e. Staining strategies and procedures: Coomassie Brilliant blue R/G 250, Silver, Fluorescent stains Flamingo, Oriole, SYPRO-Ruby; Stain-free gels. f. Examples of separation of biomolecules by electrophoresis.	
	6. Solvent extraction a. Basic principle, types of extractions and application. b. Separations based on a partitioning between phases based on chemical nature and polarity of analyte. c. Introduction to Soxhlet apparatus, solid phase extraction, microwave assisted extraction, ultrasound assisted extraction, counter current extraction.	5
	7. Dialysis a. Principles and applications of equilibrium dialysis and ultrafiltration. b. Dialysis and Concentration, reverse dialysis. c. Artificial membranes, semi-permeable membranes, Donnan membrane equilibrium. d. Biological significance of osmosis and micelles.	5
	8. Chromatographic techniques: a. Introduction to chromatography: definitions, theories, principle of chromatographic technique, terms and parameters used in chromatography, classification of chromatographic methods, concept of mobile phases; gradient elution (concave, convex and linear) and stationary phases. b. Basic principles, instrumentation and application of thin-layer, paper chromatography, column chromatography, HPLC, GC, ion-exchange chromatography, affinity chromatography, molecular exclusion chromatography and adsorption chromatography. c. Special chromatographic techniques for nucleic acids: DNA cellulose chromatography, MAK hydroxyl-apatite chromatography. d. Introduction to Supercritical-Fluid Chromatography and hyphenated techniques like LCMS, GCMS.	14
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/	1. K. Wilson, J. Walker, Principles and Techniques of Practical Biochemistry; Cambridge University Press, 7th Edition, 2010.	

Readings:	2. G. D. Christian, P. K .Dasgupta, K. A. Schug, Analytical Chemistry, John Wiley & Sons, 7th Edition, 2013. 3. M. V. Parakhia, R. S. Tomar, S. Patel, B. A. Golakiya, Molecular Biology and Biotechnology, Microbial Methods, New India, 2010. 4. D. J. Homes, H. Peck, Analytical Biochemistry,Pearson education Limited,1998. 5. A. Skoog Douglas, F. James Holler, Stanley R. Crouch, Principles of Instrumental Analysis, 7th Edition, Cengage Learning, 2016. 6. D. J. Holme., H. Peck, Analytical Biochemistry, 3rd Edition, Prentice Hall 1998.
Course Outcomes:	1. Students will be able to explain the principles of various separation techniques 2. Students will be in a position to differentiate between various analytical techniques for separation and purification of biomolecules based on their principles 3. Students will be able to choose appropriate separation technique and isolate and purify biomolecules. 4. Students will be able to apply the knowledge of these techniques for designing various experiments in research and development

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-502 **Title of the Course: Molecular Biology**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	1. To introduce the students to the structure of nucleic acids, their folding and packaging inside living cells and viruses. 2.To acquaint the students with concepts of damage to DNA, the repair mechanisms initiated by the cell and the expression and regulation of genes in prokaryotes and eukaryotes.	
Content:		**No of hours**
	1. Mendelian Genetics a. Basic concepts of Mendelian genetics: Mendel's Principles, Mendel's experiment, allele, wild-type and mutant alleles, dominant and recessive allele, homozygous and heterozygous, genotype, phenotype. b. Laws of inheritance: Mendel's law of inheritance, Law of segregation, monohybrid cross, test cross, Law of independent assortment, incomplete dominance and codominance, multiple alleles. c. Prediction, expression and probability: predicting blood groups of progeny, lethal alleles, penetrance and expressivity, Probability: predicting outcome of genetic crosses.	10
	2. Structure and properties Nucleic acids a. DNA as genetic material: 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). b. RNA: Types of RNA (mRNA, antisense mRNA, rRNA, tRNA), their structure and functions. c. Functions and properties of DNA: Fundamental functions of DNA, Buoyant density, melting temperature (Tm), DNA reassociation kinetics (Cot curve analysis), DNA methylation and epigenetic effects (Agouti gene methylation, maternal diet and offspring coat colour).	12
	3. Genome organization and Packaging a. Viruses (icosahedral capsid and helical capsids) b. Prokaryotes (supercoiling, nucleosomes and nonhistone proteins) c. Eukaryotes (supercoiling, nucleosomes, histones, chromatin and chromosome). d. Heterochromatin and euchromatin, Importance of structural features of chromosome (telomere, centromere and repetitive sequences), Functions of the chromosomes.	6

	4. Model organisms and Mechanisms of gene transfer a. *Escherichia coli as* a model prokaryotic organism. b. Yeast as a model eukaryotic organism. c. Mechanisms of Gene Transfer: transformation, transduction, conjugation, plasmids (natural, artificial), episomes.	5
	5. Mechanisms of DNA damage, repair and recombination a. Mutations and mutagenic agents: 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). b. DNA repair mechanisms/ pathways: (Base excision repair, Mismatch repair, SOS repair, Photoreactivation repair, recombination repair. c. 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
	6. Flow of genetic information and expression of genes in prokaryotes and eukaryotes, **Concept of Central Dogma** a. Replication: replication of DNA, semi conservative nature of DNA replication. b. Transcription: transcription factors and machinery, formation of transcription initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation, and termination, RNA to proteins (reverse transcription). Post transcriptional modifications: attenuation, riboswitches, alternate splicing, RNA interference, RNA processing, RNA editing, and polyadenylation, RNA transport. c. Translation: structure of Ribosome (eukaryotes and prokaryotes), formation of translation initiation complex, initiation factors and their role in regulation of initiation of translation, 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.	11
	7. **Control of gene expression at transcription and translation level** a. Regulation of gene the expression of phages, viruses, prokaryotic and eukaryotic genes. b. Role of chromatin in gene expression and gene silencing.	4

	c. Role of Recognition sequences or motifs of gene regulatory proteins, Genetic switches and their role in gene expression.	
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. J.D. Watson, Molecular Biology of the Gene. Pearson/Benjamin Cummings, 2013. 2. B. Alberts, A. Johnson, Molecular biology of cell. Garland Science, 2014. 3. N. Craig, O. Cohen-fix, R. Green, Molecular Biology: Principles of Genome function. Oxford University Press, 2014. 4. H. Lodish, A. Berk, P. Matsudaira, C.A.Kaiser, M.Krieger, M.P. Scott, L. Zipursky, & J. Darnell, Molecular cell biology. W.H. Freeman, 2008.	
Course Outcomes:	1. The student will be able to outline and explain the fundamental concepts of genetics like structure and packaging of nucleic material. 2. The student will be able to illustrate and explain the mechanisms of DNA damage, repair and recombination. 3. The student will be able to describe and discuss the process of expression of genes in prokaryotes and eukaryotes. 4. The student will gain the knowledge of basic molecular processes that occur within the cell.	

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-503 **Title of the Course: Cell and Developmental Biology**

Number of Credits: **4**

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	1. The objective is to offer detailed knowledge about cell biology, various cellular organelles, the communication pathways associated with cellular processes. 2. Introduction of the fundamental concepts of organismal developmental biology. 3. The course aims to provide the students insights on basic cell culture techniques and their current applications.	
Content:		No of hours
	1. Structural organization of the cell a. Prokaryotic and eukaryotic cells. b. Animal and plant cells. c. Structure and functions of cellular and subcellular organelles.	10
	2. Biological membrane structure and function a. Structure and functions of membrane. b. Transport across cell membrane. c. Passive and active transport of molecules across biological membranes. d. membrane pumps.	5
	3. Cell division and cell cycle a. Mitosis. b. Meiosis. c. Regulation of the cell cycle.	5
	4. Cellular communication and Cell signalling a. Signal transduction pathway. b. Signalling molecules and their receptors. c. G-Protein Coupled receptors. d. Receptor Tyrosine Kinases. e. MAP kinase pathway and JAK-STAT pathway. f. Light signalling in plants. g. Bacterial chemotaxis and quorum sensing. h. Programmed cell death (Apoptosis).	10
	5. Fundamentals of organismal development a. Potency, commitment, specification, induction, competence. b. Determination and differentiation, morphogenetic gradients. c. Cell fate and cell lineages. d. Stem cells, genomic equivalence. e. Cytoplasmic determinants, imprinting and mutants.	6
	6. Early organismal development a. Gametogenesis.	6

	b. Cell surface molecules in sperm-egg recognition in animals. c. Embryo sac development and double fertilization in plants. d. Zygote formation, cleavage, blastula formation, embryonic fields gastrulation. e. Formation of germ layers in animals, embryogenesis. f. Establishment of symmetry in plants. g. Seed formation.	
	7. Plant tissue culture: techniques and applications a. Introduction to plant tissue culture and various requirements. b. Preparation for tissue culture. i. Surface sterilization of plant tissue material. ii. Basic procedure for aseptic tissue transfer. c. Tissue culture methodologies. i. Callus Culture. ii. Cell Suspension Culture, protoplast culture and hybridization. iii. Organogenesis. iv. Plant micropropagation. v. Somatic Embryogenesis. vi. Incubation and maintenance of culture. d. Applications of PTC.	6
	8. Animal tissue culture: techniques and applications a. Introduction to animal tissue culture and various requirements. b. Typical cell lines, growing mammalian cells and general maintenance of cells. c. Applications of ATC.	6
	9. Microbial culture techniques a. *In vitro* culture techniques. b. Nutrient requirements. c. Applications in industry.	6
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. Karp, G.; Cell and Molecular Biology: Concepts and experiments; John Wiley and Sons Inc., 2015; 8th Edition. 2. Lodish, H.; Berk A.; Kaiser, C. A; Krieger, M.; Bretscher, A.; HiddePloegh, Amon A.; Martin, K. C.; Molecular Cell Biology; W.H. Freeman and Company; 2016; 8th Edition. 3. Freshney, I.; Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications; Wiley-Blackwell; 2016; 7th Edition. 4. DeRobertis, E.D.P.; DeRobertis Jr. E.M.F; Cell and Molecular Biology; Saunders; 2017; 8th Edition. 5. Pelczar, M.; Reid, R.D.; Chan E.C.S.; Microbiology. MacGraw-Hill; 2001; 5th Edition. 6. Smith, R.H.; Plant tissue culture: technique and experiments; Academic	

	Press; 2012; 3rd Edition. 7. Gilbert, S.F.; Barresi M. J.; Developmental Biology; Oxford University Press; 2020; 12th Edition.
Course Outcomes:	1. Students will be able to describe the cell structure, cell division and cell cycle mechanisms, various cellular organelles and their functions. 2. Students will be able to explain the processes of transport across cell membranes, various cellular communication pathways along with their significance and understand the fundamentals of developmental biology. 3. The students will be able to apply the basic cell culture techniques needed to work in a biological research laboratory. 4. The students will be prepared for advanced courses in life science such as Cancer biology, Neurochemistry, etc.

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-521 **Title of the Course: Practical Course in Biochemistry-I**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	1. To understand principles, theory and calculations of each experiment. 2. To gain hands on preparation of all the solutions and to standardize solutions individually. 3. To develop basic understanding and skills of various instruments and techniques used for analysing biomolecules.	
Content:		No of hours
	1. **Biomolecules and Bioenergetics (Any six)** a. Estimation of reducing sugars by DNSA method. b. Colorimetric methods for protein estimation by Biuret method. c. Colorimetric methods for protein estimation by Folin-Ciocalteau methods. d. Estimation of total sugars by anthrone method. e. Estimation of amino acids (ala, tyr, trp) and protein by UV-Vis spectroscopy. f. Estimation of nucleic acid by UV-Vis spectroscopy. g. Estimation of DNA by diphenylamine method. h. Estimation of RNA by orcinol reaction.	30
	2. Analytical Biochemistry-I (Any six) a. Calibration of pH meter using standard buffer solutions and determination of pH of given unknown solution b. Preparation of acetate and phosphate buffer of different pH values using calibrated pH meter. c. Separation of mixtures of compounds (organic compounds including biomolecules) based on their chemical nature using solvent extraction. d. Separation of lipids by thin layer chromatography. e. Separation of mixtures of compounds (organic compounds including biomolecules) by thin layer chromatography. f. Column chromatographic separation of mixtures of compounds (organic compounds including biomolecules). g. Separation of amino acids by paper chromatography.	30
	3. Molecular Biology (Any six) a. Preparation and maintenance of microbial culture.	30

	b. Isolation of genomic DNA of bacterial cells. c. Estimation of quantity and purity of DNA by spectrophotometry. d. Agarose gel electrophoresis of bacterial DNA. e. PCR amplification of a specific gene using genomic DNA as a template. f. Agarose gel analysis of PCR product to determine amplicon size. g. Isolation of plasmid DNA from microbial cells. h. Agarose gel electrophoresis of plasmid DNA.	
	4. Cell Biology (Any six) a. Use of aseptic techniques of sterilization and disinfection in microbial culture. b. Isolation of microbial species from an environmental sample such as soil/water. c. Cell counting and viability of fungal/bacterial cells via spread plating. d. Primary identification and characterization of bacterial/ fungal cells via colony characterization on solid media. e. Determining the Gram character of a bacterial species via Gram's staining technique. f. Isolation of tissue, culturing and maintenance of cell lines. g. Microscopic examination and cell counting, viability testing using a haemocytometer. h. Surface sterilization of plant material, excision, aseptic tissue transfer i. Induction of callus using plant explant and micropropagation.	30
Pedagogy:	Prelab exercises / assignments / presentations / lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings:	1. Wilson K, Walker J; Principles and Techniques of Practical Biochemistry; Cambridge University Press; 2010; 7th Edition 2. Sawhney, S. K., Singh, R.; Introductory Practical Biochemistry; Narosa Publishing House; 2005. 3. Freshney, I. R.; Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications; Wiley-Blackwell; 2016; 7th Edition. 4. Kumar, D. K.; Plant tissue culture; New Central Book Agency; 2008; 1st edition.	
Course Outcomes	1. After learning the biomolecules and bioenergetics unit of the practical students will be able to skilfully handle biomolecules. Students will be able to quantify biomolecules with appropriate methods. 2. With Analytical Biochemistry-I part of this practical, students will be able to choose between the separation techniques and carry out separation and purification of biomolecules. 3. Molecular Biology unit of the practical will train the students in techniques involved in genomic DNA isolation and PCR amplification for its use in molecular research. 4. In the Cell Biology part of the practical, the students will be able to demonstrate the various cell culture techniques needed to work in a biological research laboratory.	

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-522 **Title of the Course: Practical Course in Biochemistry-II**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	1. To provide basic knowledge of environmental pollution, effects of environmental pollutants and control measures. 2. To introduce various experimental techniques for analysis of environmental samples. 3. To impart skills in isolation and analysis of bioactive compounds in plants. 4. To acquaint the students with various food adulterants, food safety and methods of their analysis.	
Content:		**No of hours**
	1. Microbial Techniques (Any six) a. Laboratory safety protocols and Preparation of media and sterilization techniques. b. Isolation and enumeration of bacterial and fungal cultures from various environmental samples. c. Identification of microbial isolates: Morphological and biochemical identification technique d. Gram staining in bacteria. e. Determinations of total viable count. f. Determination of efficacy of cell disruption by sonication. g. Density gradient separation of cell biomolecules. h. Study of bacterial growth curve.	30
	2. Analysis of bioactive compounds from plants (Any six) a. Extraction and estimation of betacarotene from fruits. b. Extraction and estimation of folic acids from vegetables. c. Extraction and estimation of lycopene from tomatoes. d. Extraction and estimation of astaxanthene from grapes. e. Separation of plant pigments using column chromatography. f. Steam distillation for extraction of essential oils. g. Determination of starch in plant tissues. h. Estimation of mineral contents in pulses by ashing method.	30
	3. Environmental analysis (Any six) a. Estimation of acidity, alkalinity of environmental water samples using titrimetry. b. Estimation of nitrate and total organic carbon using UV-Vis spectrophotometry. c. Estimation of total dissolved solids (TDS) by gravimetric determination. d. Estimation of nitrate using cadmium reduction	30

	column method. e.Estimation of total phosphorus using spectrophotometric method. f. To estimate total suspended solids (TSS) using the filter paper method. g. Isolation of xenobiotic degrading bacteria by selective enrichment. h. Calcium analysis by ethylenediaminetetraacetic acid (EDTA) titration.	
	4. Food safety analysis. (Any six) a. Study of sterilization techniques used in food safety. b. Screening and enumeration of spoilage bacteria from food samples. c. Study of spoilage fungi isolated from fruit samples. d. Assessing the quality of raw milk *via* MBRT test. e. Determination of total viable count in prepared (ready to eat) food sample. f. Determination of adulterants in food (turmeric- metanil yellow/ chilli powder- congored) g. Testing the adulteration/ rancidity in oils. h. Assessment of surface sterilization using swab and rinse method	30
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. K. Wilson, J. Walker, Principles and Techniques of Practical Biochemistry; Cambridge University Press, 7th Edition,2010. 2. S. K. Sawhney, R. Singh, Introductory Practical Biochemistry, Narosa Publishing House, 2005. 3. B. SMT and B. Poornima B, Food Science & Quality Control, Centrum Press First , 1st Edition, 2014. 4. A. Y. Sathe, A first course in Food Analysis. New Age International Pvt. Ltd.,, 1st Edition.1999.	
Course Outcomes:	1. Students will be able to extract a bioactive compound from plants and perform a quantitative analysis. 2. Students will be in position to use different techniques for qualitative and quantitative analysis of environmental samples. 3. Students will be able to identify adulterants and pathogens in food. 4. Students will be able to explain the origin and harmful effects of toxic chemicals in the environment.	

Semester II

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-504 **Title of the Course: Enzymology**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	1. To introduce enzymes and the important role they play in metabolism 2. To develop knowledge regarding basic concepts of enzyme such as enzyme activity, kinetics and mechanism of action. 3. To develop understanding about techniques used for purification of enzymes.	
Content:		**No of hours**
	1. Introduction to enzymes a. Types of enzymes: Simple enzymes, conjugated enzymes. b. Cofactors and prosthetic groups: Coenzymes and cofactors and their role in enzyme activity, prosthetic group, metalloenzymes. c. Nomenclature and classification of enzymes. d. Structure and specific sites: Enzyme structure, enzyme-substrate complex, binding sites, concept of active site, stereo-specificity. e. Enzymes as catalysts: lock and key model, induced fit model, role of enzymes to increase reaction rates: transition state theory and activation energy.	10
	2. Enzyme Kinetics and Enzyme-substrate interactions a. Enzyme activity, Enzyme Assay, specific activity (Definition and units). b. Enzyme kinetics: Michaelis-Menten Equation: formula and derivation, Line-Weaver Burk plot for one substrate reactions. c. Significance of Vmax and Km. d. Kinetics of bi- or multi reactant system. e. Effect of pH, temperature on enzymes. f. Enzyme inhibition: reversible (competitive, uncompetitive, mixed inhibition) and irreversible inhibition. g. Enzyme turnover: Ks, Kd and measurement of enzyme turnover. h. Correlation between the rates of enzyme turnover and structure and function of enzymes, significance of enzyme turnover. i. Mechanism of enzyme degradation.	16
	3. Mechanism of Enzyme Action and Enzyme regulation a. Mechanism of Enzyme catalysis, Determination of active centre. b. Identification of functional groups, Factors affecting catalytic efficiency: proximity, orientation, strain, Enzyme catalytic strategies: covalent, acid -base catalysis, metal ion catalysis. c. Enzyme Regulation: control of enzyme activity, control of enzyme availability, inhibitor or enhancer molecules.	14

	d. Mechanisms of enzyme regulation and their significance in metabolism: i. Allosteric regulation (aspartate transcarbamylase). ii. Reversible covalent modification (glycogen phosphorylase, glutaminesynthetase). iii.Feedback inhibition and feedback repression.	
	4. Enzyme systems a. Zymogens and Isozymes. a. Multienzyme systems: disassociated system (catabolic enzymes), multienzyme complex (pyruvate dehydrogenase) membrane-bound system (electron carrying enzymes). b. Nucleic acid as catalysts: Ribozyme, DNAzyme; Abzyme. c. Mechanism of action of lysozyme, chymotrypsin, aspartate protease, RNase A.	12
	5. Enzyme purification techniques a. Isolation of intracellular and extracellular enzymes from plant and animal tissues and microbial cells. b. Separation and purification of enzymes by differential centrifugation, salt precipitation, dialysis, ultrafiltration, molecular exclusion chromatography, affinity chromatography, ion exchange chromatography. c. Determination of Enzyme activity, Specific activity and fold purification as criteria of purity of enzymes. d. Zymograms. e. Molecular weight determination by PAGE, SDS-PAGE.	8
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. D.T. Plummer, An introduction to practical biochemistry. TATA McGraw Hill, 2006. 2. R.O. Oktore, Essentials of Enzymology. Xlibris-US, 2015. 3. T.D.H. Bugg, Introduction to enzymes and coenzyme chemistry. Wiley, 2012. 4. J.M.Berg, L.Stryer, J. Tymoczko, G. Gatto, Biochemistry. W.H. Freeman, 2019. 5. N. Price and L. Stevens, Fundamentals of Enzymology. Oxford University Press, 1999. 6. D.L.Nelson, M.M. Cox, A.L. Lehninger, Principles of Biochemistry. WH Freeman 2017.	
Course Outcomes:	1. The students will be able to classify enzymes 2. The students will be able to discuss different types of enzymes, regulation and kinetics. 3. The students will be able to describe the mechanism of action of enzymes and the strategies they use for catalysis 4. The students will be able to determine and choose biochemical techniques for purification of enzymes.	

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-505 **Title of the Course: Analytical Biochemistry-II**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	1. To Introduce various electro-analytical, imaging and spectral characterisation techniques for analysis. 2. To evaluate the utility of various analytical techniques as a qualitative and quantitative tool. 3. To develop concepts in techniques and instruments required for macromolecule structure determination and other techniques such as tracers for metabolic pathways.	
Content:		**No. of hours**
	1. Automation in biochemistry a. Definition and history. b. Discrete analysers and flow analysis. c. Advantages and disadvantages of automation.	4
	2.Electroanalytical methods a. Introduction to ion selective and gas sensing electrodes and their applications. b. Introduction to potentiometry, conductometry, coulometry and voltammetry. c. Introductions to biosensors.	7
	3. Optical methods of analysis a. Theory, instrumentation and application of nephelometry. b. Theory, instrumentation and application of turbidimetry. c. Theory, instrumentation and application of UV-visible spectrophotometry. d. Theory, instrumentation and application of fluorometric analysis. e. Theory, instrumentation and application of flame emission photometry and Atomic absorption spectrophotometry.	12
	4. Microscopy and Bioimaging a. Imaging living cells and tissues and measuring cellular dynamics. Theory of microscopy, basic aspects of compound microscope. b. Light microscopy: Theory, instrumentation and applications of bright field, dark field, phase-contrast, inverted microscopy. c. Principle and application of fluorescence microscopy, confocal scanning microscopy, epifluorescence and immuno-fluorescence microscopy. d. Electron microscopy: Theory, instrumentation and applications of atomic force microscopy (AFM), scanning electron microscopy (SEM), transmission electron	11

	microscopy (TEM). Optical tweezers, photography.	
	5. Radioisotope techniques a. Nature of radioactivity and its detection, measurement of radioactivity, Disintegration kinetics. b. Radio-activity counters and radioanalysis – GM Counter, Scintillation Counter, Isotope dilution analysis. c. Theory and application of Autoradiography d. Theory and application of radiorespirometry. e. Tracer techniques for metabolic pathways. f. Safety measures in handling radioisotopes.	8
	6.Spectroscopic techniques for structure determination of biomolecules: a. Principles, application and profile analysis of: FTIR, NMR, ESR, Single crystal X-ray diffraction, optical rotatory dispersion, circular dichroism. b. Structure elucidation of metabolites using combined spectroscopic data.	12
	7. Mass Spectrometry: a. Principle, components, working and applications of mass spectrometer. b. Different types of ionization methods used in mass spectrometer (CI, EI, ESI, FAB). c. Different types of mass analysers used in mass spectrometers (magnetic sector, ion trap, quadrupole), MALDI-MS, MALDI-TOF-MS, ICP-MS. d. Structural information by tandem mass spectrometry.	6
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. Wilson, K.; Walker, J.; Principles and Techniques of Practical Biochemistry; Cambridge University Press; 2010,7th Edition. 2. Homes, D. J.; Peck, H.; Analytical Biochemistry; Pearson Education Limited; 1998, 3rd Edition. 3. de Hoffmann, E.; Stroobant, V.; Mass Spectrometry: Principles and Applications; John Wiley & Sons Ltd; 2007, 3rd Edition. 4. Christian, G. D.; Dasgupta, P. K.; Schug, K. A.; Analytical Chemistry; John Wiley & Sons; 2013, 7th Edition. 5. Skoog, D. A.; Holler, F. J.; Crouch, S. R. Principles of Instrumental Analysis; Cengage Learning; 2016,7th Edition. 6. Parakhia, M. V.; Tomar, R. S.; Patel, S.; Golakiya, B. A.; Molecular Biology and Biotechnology: Microbial Methods; New India, 2010.	
Course Outcomes:	1. Students will be in a position to explain the principles of various techniques. 2. Students will be able to differentiate between various analytical techniques based on their theory and sensitivity achieved. 3. Students will be able to choose between various techniques of	

	structure elucidation based on the information desired and interpret the data obtained to a fair level. 4. Students will be able to apply the knowledge of various techniques for designing experiments in research and development.

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-506 **Title of the Course: Immunology and Immunotechniques**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	1. 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. 2. This course will enable students to understand the role of the immune system in eliciting immune response.	
Content:		**No of hours**
	1. Cells and Organs of the Immune system a. Cells of the immune systems. i. Hematopoiesis; Lymphocytes and Antigen presenting cells (APCs). ii. T cells: Maturation; Activation and Proliferation; T cells subsets and their functions; T cell receptor; structure and organization. iii. B cells: Maturation, Activation and Proliferation; Functions; T cell receptor, Structure and Organization. b. Organs of the immune systems. i. Primary and secondary lymphoid organs: Structure and function.	10
	2. Innate Immune response a. Mechanical barriers to infection. b. Physiological factors contributing to innate immunity. c. Inflammatory response: Mechanism and mediators involved. d. Phagocytic system: Activation of macrophages and mechanism of phagocytosis. e. Complement system: Components; Properties; function; Activation of complement pathways (Classical, Alternative and lectin pathways); Consequences of complement activation; Complement fixation test.	8
	3. Adaptive immune response a. Cell-mediated and Humoral immunity: primary and secondary immune response. b. 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; self MHC restriction of T cells; Gene organisation and concept of MHC polymorphism; MHC expression and its regulation. c. Antigen processing and presentation pathways: Cytosolic	8

	and Endocytic pathways.	
	4. Antigens and Antibodies a. Antigens: Chemical complexity and molecular property of Antigens; Immunogens; Haptens; Epitopes; Antigenicity and Immunogenicity. b. Antibodies: i. Structure and function of various classes of immunoglobulins. ii. Antigenic determinants on immunoglobulins. iii. Monoclonal and Polyclonal antibodies: their production by hybridoma technology and clinical uses.	6
	5. Immunogenetics a. Theories of antibody formation. b. Generation of antibody diversity. c. Class switching among constant-region genes.	4
	6. Immune effector mechanisms a. Cytokines: properties; Receptors and Functions. b. Immunological tolerance. c. Hypersensitivity reactions: Classification and mechanisms. d. Autoimmunity: Pathogenesis; Classification (Organ-specific autoimmune disease and Systemic Autoimmune diseases).	6
	7.Immune system in health and disease: a. Immunodeficiencies: Primary and secondary immunodeficiencies. b. Transplantation immunology: Definition; Immunologic Basis of Graft Rejection; Allograft rejection; Clinical features of graft rejection; Graft v/s host reaction; Immune tolerance to allograft; Immunosuppressive therapy for prevention of graft rejection. c. Concepts of vaccines: whole-organism vaccines; recombinant vaccines; DNA vaccine; synthetic peptide and multivalent subunit vaccines.	8
	8. Immunotechniques: a. Antigen – antibody reactions: General features of Ag-Ab reactions, Stages of Ag-Ab reactions (primary and secondary). b. Principles and techniques: *in vitro* precipitation; agglutination; immunofluorescence; immunodiffusion; immunoelectrophoretic; ELISA; RIA; Avidin-Biotin complex (ABC) method; Western blotting; Immunohistochemistry; flow cytometry.	10

Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.
References/ Readings:	1. Owen, J.; Punt, J.; Stranford, S.; Patricia, J.; Kuby Immunology, WH Freeman and Company, 2012, 8th Edition. 2. Martins, S.J.; Burton, D.R.; Roitt, I.M.; Delves, P.J.; Roitt's Essential Immunology; Wiley Blackwell; 2017; 13th Edition. 3. Abbas, A.; Lichtman, A.; Pillai, S.; Cellular and Molecular Immunology; Ed. Saunders; Elsevier; 2014; 8th Edition. 4. Parija, S.C.; Textbook of Microbiology and Immunology; Elsevier; 2012; 2nd Edition. 5. Hay, F.C.; Westwood, O.M.R; Practical Immunology; Cold spring Harbour; 2002; 4th Edition.
Course Outcomes:	1. Students will be able to visualize the importance of the immune system in the human body to fight pathogens. 2. Students will be able to schematize mechanisms of Immunological response. 3. Students will be able to illustrate the importance of antigen-antibody interactions and various serological techniques for immunological research. 4. Students will be able to devise strategies in designing immunological experiments based on their understanding about immunological processes.

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-507 **Title of the Course: Industrial Biochemistry**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	1. To Introduce various techniques used for handling and processing of biomolecule. 2. To evaluate the utility of various techniques as a qualitative and quantitative tool for handing biomolecule on industrial scale. 3. To develop the concepts for managing biomolecules at commercial scale.	
Content:		**No of hours**
	1. Fermentation and bioreactors a. Introduction to Fermentation: Industrial fermentation and its range, advantages of industrial fermentations over chemical manufacturing process, types of fermentation processes: submerged and solid-state fermentation, modes of fermentation: batch,fed-batch and continuous, microbial growth curve and its use in designing modes of fermentation. b. Fermenters: Basic components of a fermenter, types of fermenters with their advantages and disadvantages, solid state fermentation, anaerobic fermentation. c. Significance and control of various fermentation parameters: Maintenance of aseptic conditions, methods of sterilisation, aeration and agitation, Industrial media and the nutrition of industrial organisms, scale up and scale down of a fermentation process, rheological properties of fermenter, Online and offline monitoring, computerization of fermenter operation. D. Downstream processing: Steps of downstream processing: Details of removal of insolubles, disruption of cell, isolation/extraction/purification, recovery and final product isolation of fermentation products	16
	2. Food technology a. Characteristics of industrial microorganisms; strain improvement; use of auxotrophic mutants; cultivation of microorganisms. b. Introduction to processed foods: Introduction about different food industries, general properties and microorganisms involved in it c. Industrial production of few food products; i. Production of foods made from milk: Cheese, Probiotics – yoghurt/ curd. ii. Production of alcohol-based fermentation products: wine, beer, vinegar. iii. Production of oriental fermented foods: Soy sauce, tofu, tempeh.	16

	iv. Production of Indian fermented foods: Idli, dosa, dokhla. v. Production of ethnic fermented foods and beverages of Goa.	
	3.Industrial production of biochemically important products a. Production of industrially important proteins. i. Industrially important enzymes - amylase / protease / pectinase / lipase. b. Production of industrially important carbohydrates. i. Manufacturing and refining of cane sugar, pectin/cellulose ii. Manufacturing of polysaccharides. Plant polysaccharide (Gum Arabic), microbial polysaccharides, modified carbohydrates – modified starches, modified celluloses c. Production of industrially important lipids. i. Extraction and refining of vegetable oils and animal fats in general. ii. Extraction and applications of chlorophyll, carotene, lycopene, curcumin, and essential oils.	9
	4.Production of pharmaceuticals, nutraceuticals and biochemicals a. Production of Antibiotics: penicillins/ streptomycins. b. Production of Vitamins: B12/ascorbic acid. c . Production of Amino acids: lysine/glutamine. d. Production of Alcohol: ethanol. e. Production of Organic acid: citric acid/ lactic acid.	9
	5.Microbial cells as fermentation products: a. Production of Baker's yeast. b. Single cell proteins/Spirulina. c. Bacterial insecticides. d. Mushrooms.	5
	6. Immobilized Biocatalysts: Enzymes and Cells a. Rationale for immobilizing enzymes and whole cells. b. Methods for enzyme and whole cell immobilization, supports and their selection. c. Properties of immobilized biocatalysts. d. Industrial applications of immobilized biocatalysts.	5
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. Okafor N., Modern Industrial Microbiology and Biotechnology, Science Publishers, 2007, 4th Edition. 2. Casida, JR L. E.; Industrial Microbiology, New Age International Publishers, 2019, 2nd Edition. 3. Clarke, W.; Biotechnology: Industrial Microbiology a Textbook, CBS Publishers and distributers, 2016. 4. TamangJ P., Ethnic Fermented Foods and Beverages of India: Science History and Culture. Springer Nature,2020. 5. Frazier W. C. and Westhoff D. C., Food Microbiology –Tata McGraw Hill Publishers, 1995.	

	6. Stanbury P. F., Whitakar A. and Hall S.; Principles of fermentation technology, Butterworth-Heinemann, 1995, 2nd Edition. 7. Kuila, A., Sharma, V.; Principles and Applications of Fermentation Technology, Wiley-Scrivener Publishing, 2019, 1st Edition.
Course Outcomes:	1. Students will be able to understand the principles of biochemistry techniques used in various settings of industrial processes. 2. Students will be able to apply the principles of techniques learned in biochemistry in various settings of industrial processes. 3. Students will be able to develop strategies for production of various types of biomolecules. 4. Students will be capable to handle various tools used for production and recovery of products on industrial site.

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-523 **Title of the Course: Practical Course in Biochemistry-III**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	This course develops basic understanding and skills of various techniques and instruments in biochemistry research, Immunology and Environmental science.	
Content:		**No of hours**
	1. Enzymology (Any six) a. Assay of enzyme activity, rate of reaction. b. Optimization of parameters for enzyme activity. c. Determination of specific activity of enzyme. d. Determination of Km, Vmax. e. Screening of microbes for production of enzymes (amylases, cellulases). f. Purification of enzyme by salting-out using ammonium sulphate. g. Dialysis of the precipitated enzyme. h. Purification of enzyme by Gel filtration. i. Determination of fold purification, percentage recovery of protein. j. Molecular weight determination of the enzyme by SDS-PAGE.	30
	2. Analytical Biochemistry – II (Any six) a. Visualization of cells by Light microscopy. b. Visualization of cells by Phase contrast microscopy. c. Verification of Beer lambert law using biomolecules or organic compounds. d. Qualitative analysis of any one of the given amino acids or organic compounds using calorimetry. e. To perform UV-Visible spectroscopic studies to determine extinction coefficient of different organic compounds including biomolecules. (Tryptophan, Tyrosine, Methionine, Proline, Arginine, Cysteine, Cystine, Histidine). f. Calibration of spectrofluorometer using quinine sulphate. g. Analysis of biomolecule/ organic molecule using GC. h. Analysis of biomolecule/ organic molecule using IR. i. Analysis of biomolecule/ organic molecule NMR. j. Analysis of biomolecule/ organic molecule LC-MS. k. Elucidation of structure of cellular metabolites using IR, NMR and Mass profiles.	30

	3. Immunology and Immunotechniques (Any six) a. Agglutination assays. i. Haemagglutination: Determination of ABO and Rh blood group. ii. Latex bead agglutination: Rheumatoid Arthritis factor determination. b. Immunodiffusion assays. i. Single Immunodiffusion. ii. Double Immunodiffusion: Ag-Ab pattern and Antibody titration. c. VDRL test. d. Widal test: Slide and tube method. e. Rapid tests. i. Malarial antigens Pv/Pf. ii. Dengue IgM and IgG antibodies. iii. Hepatitis HBsAg. f. ELISA: Dot-ELISA method. g. Immunoelectrophoresis. h. Determination of Immunoglobulins. i. Precipitation of antibodies with $(NH_4)_2 SO_4$. ii. Determination of antibody concentration. iii. Separation and visualization of immunoglobulins by SDS PAGE.	30
	4. Industrial biochemistry (Any six) a. Production of wine and monitoring of sugar reduction during the fermentation b. Production of wine and monitoring of alcohol production during fermentation c. Production of vinegar and estimation of acetic acid d. Isolation and screening of probiotics e. Study of fermentation process of milk to curd by microscopic observation and monitoring of pH. f. Study fermentation of dosa batter and monitor pH and microbial load in given dosa batter samples g. To perform comparative study of rheology of substrate solutions and fermentation broth (any Indian fermentation products (Idli/ dosa)	30
Pedagogy:	Prelab exercises / assignments / presentations / lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings:	1. Berg, J.M., Stryer, L., Tymoczko, J., Gatto, G., Biochemistry, WH Freeman, 2019, 9th Edition. 2. Prescott, H. Laboratory exercise in Microbiology, MacGraw-Hill Companies, 2002, 5th Edition. 3. Vogel's Text book of Quantitative Inorganic Analysis, Pearson Education, Asia, 2000, 6th Edition. 4. Owen, J.; Punt,J.; Stranford, S.; Patricia, J.; Kuby Immunology, WH Freeman and Company, 2012, 8th Edition.	

Course Outcomes:	1. Enzymology part of this practical will impart skills on isolation of enzymes from living cells, their purification and understanding their substrate interactions. 2. From the Analytical Biochemistry-II part of this practical, students will be able to explain the principle and working of basic instruments in analytical laboratories and interpret spectral data to elucidate structures of certain secondary metabolites. 3. From the Industrial Biochemistry part of this course, students will develop the skills required for production and analysis of various industrially important metabolites. 4. From the Immunology and Immunotechniques unit of this practical students will be able to evaluate and design various techniques in Immunological research.

Name of the programme: M.Sc. Part-I (Biochemistry)

Course Code: CHB-524 **Title of the Course: Plant Biochemistry**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have graduate level knowledge either in chemical or life sciences or should have qualified change of discipline test.	
Course Objectives:	1. To acquaint students with biochemistry of plants and the mechanisms of photosynthesis. 2. To introduce to students the details of pigment production, toxin production, antioxidative and stress tolerance mechanisms in plants.	
Content:		**No of hours**
	1.Electron transport system in plants a. Oxidative phosphorylation in plants (cyclic and non-cyclic photo-phosphorylations) b. Mitochondrial respiratory complexes c. Order and organization of electron carriers d. Electrochemical gradient e. Chemiosmotic theory f. ATP synthase and mechanism of ATP synthesis g. Generation of NADPH	10
	2. Nitrate assimilation a. Structural features of nitrate reductase and nitrite reductase b. Incorporation of ammonia into organic compounds c. Regulation of nitrate assimilation d. Nitrogen fixing plants	8
	3. Photosynthesis a. Photosynthetic apparatus, pigments of photosynthesis, the role of carotenoids b. Photosystems I and II, their location c. Hill reaction, complexes associated with thylakoid membranes d. Light-harvesting complexes, e. Path of carbon in photosynthesis: C3 and C4 pathway of carbon, reduction and its regulation, Photorespiration.	10
	4. Special features of secondary plant metabolism a. Terpenes (classification, biosynthesis), lignin, tannins, pigments, phytochrome, waxes, alkaloids, b. Biosynthesis of nicotine c. Functions of alkaloids, d. Cell wall components.	8
	5. Toxins of plant origin a. Phytohemagglutinins, lathyrogens, nitriles, protease inhibitors, glycosides, proteinaceous toxins, tannins, oxalates, anti-vitamins, volatile oils, furocoumarins, lectins, solanins and chaconines b. Mechanism of toxin action c. Toxicological effects of plant toxin	8
	6. Stress metabolism in plants a. Environmental stresses, salinity, water stress, heat, chilling, anaerobiosis, pathogenesis, heavy metals,	10

	radiations and their impact on plant growth and metabolism b. Criteria of stress tolerance.	
	7.Antioxidative defence system in plants a. Reactive oxygen species and their generation Enzymic and non-enzymic components of antioxidative defence mechanism.	6
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. M.K. Campbell, 2012. Biochemistry. 7 th edition. Boston: Cengage Learning, 2012. 2. L. Taiz, and E. Zeiger, Plant Physiology. Sinauer Associates Inc., U.S.A, 2010.. 3. W.G. Hopkins and Huner, N.P. 2009. Introduction to Plant Physiology. U.S.A. John Wiley & Sons, 2008 4. P.N. Campbell, and A.D. Smith, Biochemistry Illustrated. London: Churchill Livingstone, 2011. 5. J.M. Berg, J.L. Tymoczko, and L. Stryer, Biochemistry, New York: W.H. Freeman and Company, 2011. 6. D.L.Nelson, and M.M. Cox, A.L. Lehninger, Lehninger Principles of Biochemistry. New York: W. H. Freeman and Company, 2008.	
Course Outcomes:	1.The students will be able to describe and outline the mechanisms of plant photophosphorylation, photosynthesis 2.The students will be able explain the functions of plant pigments and other biomolecules. 3.The students will be able to explain mechanisms of pigment production 4.The students will be able to develop understanding of stress tolerance and antioxidant production by plants.	

Semester III

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-600 **Title of the Course: Practical Course in Biochemistry-IV**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have studied biochemistry courses at MSc. part I level.	
Course Objectives:	1. To acquaint the students with various methods of analyses of clinical samples for metabolic diseases/ disorders essential in pathological laboratories. 2. To develop skills in the analysis of water samples according to critical parameters. 3. To impart an understanding of various statistical operations needed to process biological data and improve technical writing skills. 4. To develop techniques for handling, identification, and culturing of microorganisms.	
Content:	**A. Medical Biochemistry** Introduction to use of autoanalyzer and Rapid test for various clinical samples **1. Analysis of blood sample: (ANY THREE)** a. Examination of Haemoglobin (Hb) content of blood by copper sulphate method or Sahli's method; determination of erythrocyte sedimentation rate (ESR) of blood by Westergren method and ABO Blood grouping for determination of blood group. b. Examination of clotting time of blood by capillary tube method and examination of total cell and differential cell (TC/DC) counts of blood sample. c. Examination of blood glucose by glucose oxidase method or Folin-Wu method or HbA1c rapid test d. Examination of blood cholesterol level by Zak's method. e. Rapid test for drug abuse f. Rapid test for pregnancy **2. Liver function tests: (ANY ONE)** a. Estimation of serum alanine transaminase (SGPT) and aspartate transaminase (SGOT) by Reitman and Frankel method. b. Estimation of serum bilirubin level by Malloy and Evelyn method **3. Renal function tests:** a. Physical examination of urine: assessment of volume, appearance, odour, color, pH and specific gravity and microscopic examination of urine: assessment of crystals, casts, cells in urine sample.	**No of hours** 30

	b. Chemical examination of urine: **(ANY ONE)** i. Estimation of glucose in urine sample by Benedict's method and estimation of albumin content in urine sample by Sulfosalicylic acid method. ii. Estimation of blood urea by Diacetyl-monoxime method.	
	B. Bioprospecting and Bioremediation (ANY FIVE) **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*. 4. Biotransformation of xenobiotics. 5. Bioassay: Antibiotic assays 6. Techniques of strain improvement: a. Using UV radiations b. Using a Chemical mutagen 7. Production of protoplast: a. Using lytic enzymes b. Using antibiotics. 8. Immobilization of enzymes and determination of its activity. 9. Separation and purification of secondary metabolites from microbial extracts using preparative HPLC.	25
	C. Biostatistics and technical writing (ANY FIVE) 1. Use of graphical modes to represent biological data 2. Developing understanding for linear equation analysis (regression analysis). 3. To study normal distribution curve 4. To carry out Hypothesis testing using Z-test and t-test 5. To develop scientific abstract writing skills. 6. To develop scientific reports writing skill 7. Formation of frequency distribution and calculation of descriptive measures-mean, median, mode, variance, standard deviation and standard error	25
	D. Clinical Microbiology and food biochemistry (ANY FIVE) 1. Study of the bacterial growth curve. 2. Microscopic examination of blood films for identification of malarial parasites/ Rapid test for malaria. 3. Study and identification of bacterial pathogens. 4. Antibiotic susceptibility testing for bacterial	25

	pathogens. 5. Study and identification of fungi. 6. Examination of foods and determination of food spoilage microorganisms 7. Study of Enzymatic browning of fruits 8. Study of Auto Oxidation and Rancidity of fats.	
	E. QA and QC in pharmaceuticals (ANY THREE) 1. Qualitative and Quantitative tests of Paracetamol/Aspirin as per IP Monograph 2. To study the dissolution rate of sustained release Diclofenac/Theophylline tablets IP. 3. To develop and validate the analytical method of any one drug using high performance liquid chromatography. 4. To identify the given drug amongst paracetamol, aspirin, and caffeine citrate with the help of thin layer chromatography and calculate its Rf value. 5. Titrimetric Assay of the following bulk drugs: Chloramphenicol capsules IP /Furosemide injection IP/Ketoprofen/ Phenytoin (Any 1) 6. UV Spectrophotometric Assay of the following drugs (in different dosage forms): Mefenamic acid/ Furosemide/ Chloramphenicol (Any 1)	15
Pedagogy:	Prelab exercises / assignments / presentations / lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings:	1. G. Damodaran, Practical Biochemistry. Jaypee Brothers Medical Publishers, 2011. 2. S. Mohanty, Practical clinical Biochemistry. Jaypee Brothers Medical Publishers, 2013. 3. H. Glasman-Deal, Science Research Writing. Imperial College Press, 2010. 4. Vogel's Text book of Quantitative Inorganic Analysis, Pearson Education, Asia, 2000. 5. K. Wilson and J. Walker, Principles and Techniques of Practical Biochemistry. Cambridge University Press, 2010. 6. S. K. Sawhney, R. Singh, Introductory Practical Biochemistry. Narosa Publishing House, 2005. 7. B. Poornima, Food Science & Quality Control. Centrum Press First, 2014. 8. A.Y. Sathe, A first course in Food Analysis. New Age International,1999. 9. H. Prescott, Laboratory exercise in Microbiology. MacGraw-Hill Companies, 2002. 10. K. A. Connors, Text book of Pharmaceutical analysis, Wiley	

	Interscience Publication, 1990. 11. J. Moini, Pharmaceutical Laboratory Procedures, New Delhi: Cengage Learning India, 2010.
Course Outcomes:	1. Students will be able to analyse clinical samples for metabolic diseases/ disorders essential in pathological laboratories and further will be able to design various techniques in clinical biochemistry research. 2. Students will be able to evaluate water samples and assess its suitability 3. Students will be able to apply various statistical operations needed to process any biological data and have good technical writing skills. 4. Students will be in a position to handle, culture, and identify microorganisms

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-601 **Title of the Course: Practical Course in Biochemistry-V**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have studied biochemistry courses at MSc. part I level.	
Course Objectives:	1. To develop hands-on experience of skills in various instruments and techniques in animal cell and tissue culture and microbial cells. 2. To develop skills in genomics and proteomics 3. To gain experience in bioprospecting of microbes for industrial purpose 4. To study advanced analytical techniques in the separation and characterization of biomolecules.	
Content:	**A. Animal and plant tissue culture techniques and Microbial techniques (any nine)** 1. Animal tissue culture techniques: a. Laboratory safety protocols, Preparation of media and sterilization techniques. b. Primary cell culture c. Establishing cell lines d. Cell counting and viability techniques. e. Preservation of cell lines. 2. Plant tissue culture techniques: a. Laboratory safety protocols and Preparation of media and sterilization techniques. b. Germination of seeds in vitro. c. Establishment of primary culture and Micropropagation. d. Low cost strategies in plant tissue culture. 3. Microbial culture techniques: a. Laboratory safety protocols and Preparation of media and sterilization techniques. b. Isolation and enumeration of bacterial and fungal cultures from various environmental samples. c. Identification of microbial isolates: Morphological and biochemical identification techniques.	**No of hours** 45
	B. Genomics and proteomics (any six) 1. Isolation of genomic DNA from Prokaryotic cells. 2. Isolation of genomic DNA from Eukaryotic cells. 3. Isolation of RNA from prokaryotic cells 4. Isolation of plasmid DNA using Rapid boiling and Alkaline lysis method. 5. Isolation of protease degraders from soil and estimation of protease activity. 6. Quantitative Estimation of DNA and RNA	30

	7. Electrophoretic techniques and various gel staining techniques. 8. DNA: PCR amplification, electrophoresis and purification. 9. Molecular identification techniques for microbial isolates: understanding of 16s and 18s rRNA sequencing, BLAST analysis and construction of phylogenetic trees. 10. Protein identification techniques: understanding of protein sequencing, Protein BLAST, Protein Data bank (PDB) studies.	
	C. Advanced Analytical techniques in industry and research (any nine) 1. Extraction, purification and quantification of bioactive components from different source 2. Gas chromatographic analysis of volatile organic impurities in different samples 3. Purification of various analytes using advance chromatographic techniques such as size exclusion and ion exchange chromatography 4. Fluorometric analysis of the vitamins and drug molecules 5. Removal of impurity from commercial food products using adsorption on column and analysis by potentiometry. 6. Determination of sodium in plants by Flame Emission Spectroscopy 7. Determination of potassium in plants by Flame Emission Spectroscopy 8. Determination of Caffeine in tablets by UV- visible spectroscopy 9.Determination of Aspirin in tablets by UV- visible spectroscopy 10. Extraction and Separation of microbial pigments using TLC and paper chromatography 11. Qualitative and quantitative analysis of given sample using HPLC 12. Structural elucidation of amino acids (proline/tryptophan/cysteine) using various spectroscopic techniques. 13.Decolorization and crystallization of brown sugar (sucrose) with animal charcoal using gravity filtration. 14. Estimation of lead/cadmium in water sample by AES/AAS/ICP. 15. Estimation of iron/ manganese in water sample by AES/AAS/ICP. 16. Structural elucidation of carbohydrates (glucose) using various spectroscopic techniques.	45

Pedagogy:	Prelab exercises / assignments / presentations / lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings:	1. R. I. Freshney and J. R. Masters, Animal Cell Culture: A Practical Approach: No. 232. Oxford University Press, 2002. 2. R. I. Freshney, Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley-Blackwell, 2016. 3. R. H. Smith, Plant Tissue Culture: Techniques and Experiments. Academic Press, 2012. 4. Vogel's Text book of Quantitative Inorganic Analysis. Pearson Education, Asia, 2000. 5. K. Wilson and J. Walker, Principles and Techniques of Practical Biochemistry. Cambridge University Press, 2010. 6. S. K.Sawhney and R.Singh, Introductory Practical Biochemistry. Narosa Publishing House, 2005 7. B. Poornima, Food Science & Quality Control. Centrum Press First, 2014. 8. A.Y. Sathe, A first course in Food Analysi. New Age International, 1999.	
Course Outcomes:	1. Students will be able to use various instruments and techniques in tissue culture and microbial culture. 2. Students will be able to have skills in genomics and proteomics. 3. Students will be able to apply the techniques in bioprospecting of microbes for industrial purposes 4. Students will be able to use advanced analytical techniques in the separation and characterization of biomolecules.	

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-602 **Title of the Course: Medical Biochemistry**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have studied biochemistry courses at MSc. part I level.	
Course Objectives:	1. To understand the biochemistry of metabolic diseases/disorders of the human body. 2. To introduce knowledge on clinical investigations and analyses of clinical samples. 3. To provide insights on biochemistry of cancer and ageing.	
Content:		**No of hours**
	1. Analysis of Clinical sample **a. Blood sample** i. Collection and safety measures involved. ii. Composition and function: Composition of blood, RBCs, Erythropoiesis, Hemoglobin, gas transport by hemoglobin, Blood buffer system: acid-base balance and imbalance. iii. Analysis: Haemoglobin, total cell and differential cell (TC/DC) counts, Erythrocyte sedimentation Rate (ESR); Bleeding time and Clotting time, glucose; lipid profile; urea; gases: oxygen and carbon dioxide levels; pH. iv. Immunohaematology: Blood group systems – MN, Rh, ABO; hemolytic disease of newborn.	8
	b. Serum sample i. Collection and safety measures involved. ii. Analysis: Proteins, albumin/globulin ratio; bilirubin; creatinine; uric acid; electrolytes; Thyroid function tests (serum free and total T3 & T4 and serum TSH) iii. Enzymes of clinical and diagnostic importance: Enzymes as markers in the diagnosis of diseases; clinical significance of cholinesterase, alkaline and acid phosphatase, lactate dehydrogenase (LDH), creatine phosphokinase (CPK), aspartate aminotransferase (AST/SGOT), alanine aminotransferase (ALT/SGPT).	7
	c. Liver function tests (LFTs) i. Functions of the liver and liver profile in health and disease ii. Bilirubin metabolism and clinical significance iii. Classification of LFTs and their clinical significance in the diagnosis of liver diseases.	5
	d. Renal function test (RFTs)	4

	i. Urine: Composition of urine, collection and safety measures, ii. Kidney functions: Urine formation, glomerular and tubular functions, water electrolyte balance. iii. Analysis of urine/RFTs: Physical, chemical and microscopic examination.	
	e. Gastric and Pancreatic Function tests Gastric function tests (gastric analysis), hypo (achlorhydria) and hyper acidity, tests to confirm pancreatic involvement in disease.	2
	2. Metabolic disorders **a. Disorders in metabolism** i. Carbohydrates: Regulation of blood glucose, insulin and diabetes mellitus (classification, stages and diagnosis); Hypoglycaemia; Diabetic ketoacidosis. ii. Lipids: Hyperlipidaemias, clinical significance of cholesterol, hypercholesteremia, iii. Heart: Cardiovascular disease (Atherosclerosis and Coronary artery disease), hypertension iv. Proteins: Kwashiorkor, Marasmus Protein misfolding, Creutzfeldt-Jakob disease, mad cow disease, encephalopathy v. Blood Anaemia: Iron deficiency anemia, Megaloblastic anemia, Pernicious anemia, Sickle cell disease, hemolytic anemia vi. Liver: Jaundice, cirrhosis vii. Kidney: Diabetes insipidus, Renal calculi.	15
	b. Inborn errors of metabolism i. Prenatal diagnosis, newborn screening, laboratory investigations to diagnose metabolic disorders. ii. Carbohydrate: Lactose intolerance, galactosemia, Glycogen storage disease. iii. Lipids: Lysosomal storage disorders: Tay-Sach'sdisease; Gaucher's disease; Niemann Pick disease; Fabry's disease. iv. Amino acids: Phenylketonuria, Albinism v. Purine/pyrimidine: Lesch-Nyhan Syndrome, Gout. vi. Blood: Thalassemia vii. Thyroid hormone: hyperthyroidism and hypothyroidism viii. Skin: Xeroderma Pigmentosum	7
	3. Biochemistry of cancer i. Properties of cancer cells ii. Biochemistry of cancerous growth iii. Etiology of cancer cells	8

	iv. Apoptosis in carcinogenesis v. Metastasis vi. Mutagens and carcinogens vii. Oncogenic viruses: DNA viruses (Hepatitis B virus and Epstein-Barr virus) viii. RNA viruses (Rous sarcoma virus and Human T-cell lymphotropic virus-1) ix. Tumor markers x. Anticancer drugs	
	4. Biochemistry of ageing a. Definition and symptoms b. Ageing theories: Programmed theories and Error theories	4
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. Vasudevan, D. M.; Sreekumari, S., Vaidyanathan, K., Textbook of Biochemistry for Medical students, Jaypee brothers Medical publishers; 2011, 6th Edition. 2. Chattergee, M. N; Shinde, R.; Textbook of Medical Biochemistry, Jaypee brothers Medical publishers Ltd., 2012, 8th Edition. 3. Smith, C.; Mark, A. D; Lieberman, M.; Marks' Basic Medical Biochemistry: A Clinical Approach; Lippincott's William and Wilkins; 2004, 2nd Edition. 4. Gaw, A.; Cowan, R. A.; Murphy, M. J.; O'Relly, D. S. J.; Srivastava, R.; Clinical Biochemistry, Elsevier; 2013, 5th Edition.	
Course Outcomes:	1. Students will be able to explain the biochemistry of metabolic disorders/diseases caused due to imbalances and metabolic errors. 2. Students will be able to illustrate the mechanisms of cancer and aging in the human body. 3. Students will be able to employ technical knowledge for assessment of various clinical samples. 4. The students will be able to devise strategies in designing experiments based on their understanding about physiological processes.	

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-603 **Title of the Course: Nanobiotechnology**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have studied biochemistry courses at MSc. part I level.	
Course Objectives:	1. To introduce the concept of nanoparticles and nanomaterials. 2. To understand methods to develop nanoparticles from plants and microbes. 3. To familiarize students with different characterization tools, to identify bio-nanoparticle 4. To develop an understanding of applications of Bio-nanomaterials in Health, Food, and the Environment.	
Content:	**1. Introduction to biological cellular nanostructure and nanomaterials** a. Introduction to nanobiotechnology: definition; historical background; concepts. b. Basics of biology for nanobiotechnology: cell, organelles and nucleic acids as genetic material. c. Biological cellular nanostructures**:** i. Protein and Peptide based: Proteins, Bilayers and membrane arrays: ATPase Archaeal S-layers, bacteriorhodopsin ii. Eubacterial magnetosomes – greigite, magnetite. iii. DNA based: DNA molecule; self-assembled DNA nanotubes iv. Virus particles v. Diatoms d. Application of nanobiotechnology to biomineralization	**No of hours** 13
	2. Nanomaterials a. Shapes, size and properties: spherical, triangular, prisms, rods, cubes. Nanoparticles, nanocrystals, quantum dots, nanotubes and nanowires. b. Miniaturized devices in nanobiotechnology - types and applications c. Introduction to lab-on-a-chip (LOC).	7
	3. Biosynthesis of nanomaterials and characterization **a. Biosynthesis** i. Concept of top-down versus bottom-up approach. ii. Uniformity and heterogeneity.	15

	iii. Agglomeration of nanoparticles monitoring and control of agglomerates and collision efficiencies. **b. Green technologies:** nanoparticle biosynthesis using microbes, plant extracts, reductases. **c. Detection and characterization of nanoparticles: Optical:** i. Visual colour change; UV-Vis spectrum; Fluorescence, single molecule spectroscopy ii. Size imaging: Electron microscopy (SEM, TEM), light scattering, FRET microscopy. iii. Zeta Potential surface and composition: FT-IR, Raman spectroscopy, EDAX, AFM, XRD, ^{1}H NMR, ^{13}C-NMR.	
	4. Nanobiotechnological applications in health and disease - infectious and chronic. **A. Introduction to Biosensors:** i. Different classes -molecular recognition elements and transducing elements. ii. Applications of molecular recognition elements in nanosensing of different analytes iii. Various transducing elements as part of nanobiosensors. iv. Miniaturized devices in nanobiotechnology - types and applications, v. Lab on a chip concept (discussion with example) **B. Medical Applications** i. Drug development – Drug discovery; toxicity evaluation: cyto-toxicity, geno-toxicity. ii. Diagnostics – LOC technology; Imaging agents: MRI; nanosensors for early-stage cancer detection iii. Nano-optics and fluorescence-based assays iv. Drug delivery systems –Lipid and inorganic nanoparticles v. Antimicrobials – Metal/metal oxide nanoparticles against bacteria, fungi, viruses. vi. Therapeutics – Cardiovascular diseases; neurological disorders (Alzheimer's, and Parkinson's disease). Cancer therapy – quantum dots for targeted drug delivery.	15
	5. Nanobiotechnological applications in Environment and food - detection and mitigation **a. Environment analysis and remediation** i. Nanobiosensors for pollution detection ii. Water purification – Nanoadsorbents and magnetic nanoparticles	10

	iii. Bioremediation –nanoparticles for degradation of biological pollutants **b**. **Food industry** i. Magnetosomes for detection of pathogens ii. Nanobiosensors for food quality monitoring. iii. Nanobiosensors as emerging safety tools for the food industry.	
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. C. Nicolini, Nanobiotechnology & Nanobiosciences, Jenny Stanford Publishing,1st Edition, 2008. 2. C. M. Niemeyer, and C. A Mirkin, Nanobiotechnology, Concepts, Applications and perspectives, Wiley- Verlag GmbH & Co., 2004. 3. T. Pradeep, Nano: The Essentials, Understanding Nanoscience and Nanotechnology, Tata McGraw-Hill Publishing Company Limited, 1st edition 2007. 4. N. Yao and Z. L. Wang, Handbook of Microscopy for Nanotechnology. Kluwer Academic Publishers,2005. 5. C. A. Mirkin and C. M.Niemeyer, Nanobiotechnology- II, More Concepts and Applications, Wiley, Verlag GmbH &Co, 2007. 6. J.W.M Bulte and M.M.J Modo, Design and Applications of Nanoparticles in Biomedical Imaging, Springer International Publishing, 2016. 7. O. Shoseyov, and I. Levy, Nanobiotechnology-Bio Inspired Devices and Materials of the Future, Humana Press Inc, 2008. 8. M.M DeVilliers,P. Aramwit, and G.S Kwon, Nanotechnology in Drug Delivery; Springer-American Association of Pharmaceutical Scientists Press., 2009.	
Course Outcomes:	1. Students will be able to biosynthesize nanoparticles. 2. Students will be able to understand characterization of nanoparticles 3. Students will be able to apply their learned knowledge to develop Nanomaterial's. 4. Students will be able to apply concepts of Nano-biotechnology in Healthcare,Environment and Food Industry.	

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-604 **Title of the Course: Concepts in Genetic Engineering**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have studied biochemistry courses at MSc. part I level.	
Course Objectives:	1. To introduce fundamental tools and techniques in Genetic engineering. 2. To understand the mechanisms of recombinant DNA technology 3. To familiarize the students with the applications of genetic engineering in agriculture, therapeutics, environment and industry.	
Content:		**No of hours**
	1. Introduction a. Concept of genetic engineering b. History and milestones c. Introduction to gene manipulation tools (enzymes, hosts, vectors and transformation techniques).	5
	2. Tools in Recombinant DNA technology a. DNA modifying enzymes: restriction endonucleases, exonucleases, DNA ligases, terminal DNA transferase, DNA polymerases, reverse transcriptase, T4 polynucleotide kinases, alkaline phosphatase, S-1 Nuclease, mung bean nuclease, RNases. b. Gene cloning systems/Hosts: Gene cloning in *E. coli*, *Saccharomyces cerevisiae*. c. Vectors: Plasmid (pUC19, pBR 322), λ phage-based vectors, cosmid vectors, phasmid vectors, shuttle vectors, high capacity cloning vectors. d. Gene transfer techniques: Transformation, electroporation, transfection, gene gun.	16
	3. Recombinant DNA techniques: a. Preparation of probes b. Principles & applications of nucleic acid hybridization, c. Restriction mapping, RFLP, d. Polymerase chain reaction: PCR, RT- PCR, real time PCR, e. DNA Microarray f. DNA sequencing using Sanger's dideoxy chain termination method and automated sequencer g. Gene editing: Introduction to CRISPR/cas9 gene	10

	editing system.	
	4. Genetic Engineering in Biology, forensics and medicine a. Screening of genetic diseases using DNA probes (DNA diagnostics). b. Production of recombinant proteins and drugs (insulin, Antibodies), c. DNA vaccines: merits and demerits d. Edible vaccines- merits and demerits e. Application of recombinant DNA technology in paternity disputes and solving criminal cases (DNA fingerprinting)	10
	5. Genetic Engineering in Agriculture a. Importance of *Agrobacterium tumefaciens* b. Transgenic plants c. Significance of *Bacillus thuringiensis* (Bt genes) d. Biofortification of foods using genetic engineering.	8
	6. Genetic Engineering in Animal Husbandry and Aquaculture a. Development of transgenic animals b. Development of transgenic fish c. Animal cloning	6
	7. Genetically engineered microbes in industries and the environment. a. Application of genetic engineering for enzyme production. b. Bioremediation using genetically modified microbes. c. Safety and bioethics of genetically modified organisms.	5
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. R.W. Old and S.B. Primrose, Principles of Gene Manipulation: An introduction to Genetic Engineering, University of California Press, 1981. 2. B. R. Glick, J.J. Pasternak, and C.L. Patten, Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press, 2010. 3. R.Williamson, Genetic Engineering. Academic Press, 1981. 4. D.M. Glover, Gene cloning: The Mechanics of DNA Manipulation. Springer, 1984. 5. M.R. Green, and J.Sambrook, Molecular Cloning: A Laboratory Manual, New York: Cold Spring Harbor Laboratory, 2014. 6. L.G. Davis, M.D. Dibner, and J.F.Battey, Basic Methods in Molecular Biology. Elsevier, 1986.	

	7. P. Gerhardt, Methods for General and Molecular Bacteriology. Elsevier 1994. 8. T.A. Brown, Gene Cloning and DNA analysis: An introduction. UK: John Wiley and Sons, 2021.
Course Outcomes:	1. The students will be able to explain the tools and techniques involved in Genetic Engineering. 2. The students will be able to apply the techniques learnt in recombinant DNA technology. 3. They will be able to explain the significance of transgenic organisms in various sectors of human development. 4. Students will be able to understand the risks and benefits of genetically modified organisms.

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-605 **Title of the Course: Research methodology, Biostatistics and Bioethics**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have studied biochemistry courses at MSc. part I level.	
Course Objectives:	1. To develop a basic understanding of various types of biological data, its handling and processing. 2. To introduce various technical writing skills. 3. To understand various ethical considerations while studying biological data.	
Content:		**No of hours**
	1. Introduction to Research, Research Design & literature review **a. Basics of research** i. Definition and meaning of research, the significance of research, research & scientific method. ii. Types of research, criteria for good research, problems encountered by researchers in India, selecting & defining a research problem. iii. Research approaches: research methods vs methodology. iv. Basic principles of experimental designs, sampling, sample size determination, plan for data collection, methods of data collection, plan for data processing and analysis. **b. Literature Review** i. Primary and secondary Sources ii. Web sources –critical literature review iii. Hypothesis – Different types, significance, development of working hypothesis, null hypothesis iv. Research Methods: Scientific method vs arbitrary method, logical scientific methods: deductive, inductive, deductive-inductive, pattern of deductive – inductive logical process, different types of inductive logical methods	10
	2. Technical writing a. Different forms of technical writing: articles, research notes and reports in journals, review articles, monographs, dissertations, bibliographies. b. How to formulate outlines: The reasons for preparing outlines, guide for plan of writing, skeleton for the manuscript, drafting titles, subtitles, tables, illustrations.	5

	c. Parts of dissertation/research report/article: introduction, review of literature, method, results and discussion. d. Significant subtopics related to scientific writing such as content, its continuity, clarity, validity, internal consistency and objectivity e. Basic attributes for writing for grants	
	3. Introduction to Biological data **a. Basic characteristics of biological data** i. Variables and constants, discrete and continuous variables, relationship and prediction, variables in biology (measurement, ranked, attributes), derived variables (ratio, index, rates). **b. Types of measurements in biological data** i. Interval scale, ratio scale, ordinal scale, nominal scale, discrete and continuous data, exact and approximate numbers. ii. Classification of errors, decimal notation and rounding off numbers, absolute and relative errors, valid significant digits, relationship between number of valid digit and error, the error of sum, difference, product, quotient, power and root and rules of calculating digits.	10
	4. Data handling **a. Population and Sampling** i. Random samples, parameter and statistics, accuracy and precision, accuracy in observations ii. Tabulation and types of frequency distribution: relative & cumulative. iii. Graphical representation: types of graphs, preparation and their applications. **b. Measures of central tendency:** i. Characteristics of ideal measure, arithmetic mean – simple, weighted, combined, and corrected mean, limitations of arithmetic mean; ii. Median – calculation for raw data, for grouped data, for continuous series, limitations of median; iii. Mode – computation of mode for individual series, by grouping method, in a continuous frequency distribution, limitations of modes iv. Relationship between mean, median and mode **c. Measures of dispersion:** i. Variability, Range, mean deviation, coefficient of mean deviation, standard deviation (individual observations, grouped data, continuous series) ii. Variance, coefficient of variance, limitation.	15

	iii. Skewness – definition, positive, negative, purpose, measure, relative measure, iv. Karl Pearson's coefficient, Bowley's coefficient, Kelly's measure, moments.	
	5. Correlation analysis, Population Biostatistics and Hypothesis testing **a. Covariance, correlation coefficient for ungrouped and grouped data, scatter and dot diagram (graphical method)** i. Regression analysis - linear and exponential function ii. Examples: DNSA conversion by reducing sugar, survival/growth of bacteria, regression coefficients, regression analysis for linear equations. **b. Population Biostatistics** i. Concept of probability, theories of probability- additive and multiplicative theory ii. Probability distributions: binomial, poisson and normal **c Hypothesis testing**. i. Hypothesis and its types: Null and Alternative ii. Level of significance, one tailed and two tailed test, test for single mean and single proportion, critical region, level of confidence, level of significance, iii. Parametric and Non- Parametric test t-test, Z- test. F-test and ANOVA Introduction to Chi-square test	15
	6. **Bioethics** a. Bioethics: Definition, ethics in biology, role and importance of ethics in biology, basic approaches to ethics. b. Legal and regulatory values related to bioethics. c. Bioethics in Healthcare, agriculture, biotechnology, animal welfare and rights/PETA in research, wildlife conservation and management, commercialization in scientific research. d. Bioethics related to genetically modified organisms (GMOs): concerns about GMOs, benefit and risk of GMOs, reasoning behind acceptance and rejection of GMOs. e. Past and present bioethical conflicts in life sciences. f. Biopiracy, ethical committees, copyright, royalty, IPR and patent law, plagiarism, citation and acknowledgement. g. Bio-waste disposal: Types of biowaste, ways to dispose of biowaste.	5

Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.
References/ readings.	**1.** W .W. Daniel, Biostatistics: Basic Concepts and Methodology for the Health Sciences, Wiley publishers, 10th Edition,2014. 2. C. R. Kothari, Quantitative Techniques, Vikas Publishing House, 3 rd Edition, 2013. 3. Deal H Glasman, Science Research Writing, Imperial College Press, 2010. 4. R. K. Surya, Biostatistics for health and life sciences, Himalaya Publishing House, 1st Edition, 2010. 5. A. Annadurai, A Textbook of Biostatistics, New Age Publication, 1st edition, 2017. **6.** B. Antonisamy, P.S.Premkumar and S. Christopher, Principles and Practice of Biostatistics, Elsevier India, 1st Edition, 2017. 7. P. N. Arora and P. K. Malhan, Biostatistics, Himalaya Publishing House. 9th Edition,2006.
Course Outcomes:	1. Students will be able to collect, handle, process and present the biological data. 2. Students will be able to apply statistical methods to biological data. 3. Students will be able to develop the skills needed to successfully communicate through technical writing skills. 4. Students will be able to apply the basic concepts learned to carry out research in future.

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-621 **Title of the Course: Hormones and Neurochemistry**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have studied life sciences at M.Sc. Part I Level	
Course Objectives:	1. To develop knowledge on the human endocrine system and its role in human physiology. 2. To acquaint students with the mechanism of hormone action, their regulation and clinical disorders associated with them. 3. To develop insights into the structure and organization of a nervous system, sensory organs and their functions. 4. To develop a basic understanding of the significance of neurotransmitters. 5. To introduce the biochemistry of mental disorders.	
Content:	**Hormones**	**No of hours**
	1. Introduction to hormones a. Definition, history, classification, and mechanism of action, History of hormones, Classification of hormones. b. Understanding of endocrine system, Pathways of hormone release, c. Signal transduction pathways, second messengers, regulation of signaling Pathways. d. Hormones and their receptors: cell surface receptor, signaling through G-protein coupled receptors, Steroid hormone receptors, Thyroid hormone receptors e. Mechanism of sensitization & desensitization of hormone receptors	6
	1. Stimulus, regulation of biosynthesis and release of hormones a. Hypothalamic Hormones: CRH, TRH, GnRH, PRL/PRIH, GHRH/GHRIH b. Anterior Pituitary hormones: Growth hormone, Prolactin, POMC peptide family, LH, FSH, TSH c. Posterior Pituitary Hormones: Vasopressin, Oxytocin d. Adrenal Cortex Hormones: Aldosterone (renin angiotensin system) & cortisol e. Hormones of Adrenal Medulla: Epinephrine and	9

	norepinephrine Hormones regulating Ca2+ Homeostasis: PTH, Vitamin D, Calcitonin f. Pancreatic Hormones: Insulin, Glucagon. g. GI tract Hormones: Gastrin, Secretin, CCK, GIP, Ghrelin.	
	h. Reproductive hormones and hormones by organs with endocrine function: a. Reproductive Hormones: Male and female Sex hormones, interplay of hormones during reproductive cycle, pregnancy, parturition and lactation. Introduction to rapid test for pregnancy. b. Role of oral contraceptives. c. Other organs with endocrine function: Heart (ANP), Kidney (erythropoietin), Liver (angiotensinogen, IGF-1), adipose tissue (leptin, adiponectin); growth factors: PDGF, EGF, IGF-I, II	6
	a. Biochemistry and diseases associated with hyper or hypo secretion: a. Hypothalamus and pituitary associated hormonal conditions: Goiter, Graves' disease, Cretinism, Myxedema, Hashimoto's disease, Gigantism, Acromegaly, dwarfism. b. Adrenal cortex-associated hormonal conditions: Addison's disease, Conn's syndrome, Cushing's syndrome, c. Calcium homeostasis-related hormonal conditions: Rickets, Osteomalacia, Osteoporosis. **d.** Pancreatic hormone-associated hormonal conditions: Diabetes insipidus.	9
	Neurochemistry 1. **Organization of Nervous system: Definition, parts and anatomy** a. Central Nervous system and Peripheral nervous system; Blood Brain Barrier. b. Cerebrospinal fluid: composition, function and circulation. c. Cellular components of nervous system: Nerve, neuron, neuroglial cells	4
	2. Nerve cell Membranes: **a. Structures and Functions of nerve cells and membrane transport:** i. Phospholipid bilayer, membrane proteins, Biological membrane ii. Membrane transport: Primary ion transporters, Ca2+	3

	pumps, V-ATPase pump, secondary active transport, cation antiporters, facilitators.	
	b. **Energy metabolism in brain:** Substrates for cerebral energy metabolism, regulation of the cerebral metabolic rate, glycolysis, glycogen metabolism, Pentose, phosphate shunt, Malate–aspartate shuttle, lactate metabolism, TCA, Glutamate/glutamine metabolism.	3
	3. Synaptic Transmission: a. Synapse structure, Chemical and Electrical synapses, membrane potential in steady state, Action potential generation and propagation, pre and post synaptic events.	4
	b. **Neurotransmitters and neuromodulators: Structure, functions, metabolism, receptors:** Acetylcholine, Excitatory Amino Acids (EAAs): Glutamic Acid, Inhibitory Amino Acids (IAAs): g-Aminobutyric Acid and Glycine, Serotonin (5-HT), Catecholamine, Purines (Cannabinoids), Neuropeptides and Nitric oxide.	4
	c. Sensory transduction: Vision, Olfaction and taste, Hearing and balance, touch	3
	d. **Biochemistry of memory; mental and neurodegenerative disease**: i. Biochemistry of memory: Learning and memory; Divisions of memory (Qualitative and Quantitative categories); Synaptic signalling in learning and memory ii. Mental illness: Depression, Schizophrenia iii. Neurodegenerative diseases: Alzheimer's disease, Parkinson's disease, Huntington's disease, Dementia	6
	e. **CNS active drugs and drugs of abuse: classification and mode of action** Drugs of abuse: Opiates, Nicotine, alcohol: Molecular mechanisms, receptors and signalling	3
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. B. Kline and W.G. Rossmanith, Hormones and the endocrine system. Springer, 2016. 2. I.R. Ilie, Introduction to endocrinology. Springer, 2020. 3. J.M. Berg, L.Stryer, J.Tymoczko, G.Gatto, Biochemistry. W.H. Freeman, 2019. 4. C.K. Mathews and K.E. van Holde and K.G. Ahern, Biochemistry.	

	Pearson Publishers, 1999. 5. D. L.Nelson, M. M.Cox, and A.L. Lehninger, Lehninger Principles of Biochemistry. WH Freeman, 2017. 6. A. W. Norman, G. Litwack, Hormones. Elsevier, 1997. 7. G. David, and S. Dolores, Greenspan's Basic and Clinical Endocrinology. Mc Graw Hill Educatio 2018, 8. A. Belfiore and D. Leroith, Principles of Endocrinology and hormone action. Springer, 2018. 9. R.W. Albers, S.T. Brady, D. L.Price, Basic neurochemistry: Molecular, cellular and medical aspects. Elsevier Academic Press publishers, 2006. 10. C.U.M, Smith, Elements of Molecular Neurobiology. John Wiley & Sons Ltd., 2002. 11. E.R.Kandel, J.H. Swartchz, T.M.Jesselle, Principles of Neural science. New York:McGraw-Hill, 2000. 12. B. Mathew and T. Parambi, Principles of Neurochemistry: Fundamentals and Applications. Singapore: Springer, 2020.
Course Outcomes:	1. Students will be able to apply the knowledge of the signalling mechanisms of different hormones in the human system. 2. The students will also be able to correlate the diseases associated with hormonal imbalance and the biochemistry behind them. 3. Students will be able to explain the significance of the nervous system for the normal functioning of the human body. 4. Students will be able to illustrate the role of neurotransmitters in signal generation and the biochemistry of mental disorders in the human body.

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-622 **Title of the Course: Clinical Microbiology and Food Biochemistry**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have studied life sciences at M.Sc Part I Level	
Course Objectives:	1. To develop an understanding of the diseases caused by microorganisms and their biochemistry. 2. To develop a basic understanding on significance of commensal and normal microflora for human health. 3. Introduction of the fundamental concepts of food spoilage and food preservation. 4. To provide insights on quality control and good practices in the food industry.	
Content:		**No of hours**
	Clinical Microbiology **1. Introduction to Microbiology** a. Introduction to bacteriology, mycology, virology and parasitology. **b.** Sterilization and Disinfection: Introduction and its types, principle, procedure and its application, biosafety in microbiology lab, biowaste management.	3
	2. Normal microbial flora and pathogenic microorganisms a. **Introduction**: Distribution of the normal microbiota; Commensals; relationship between normal microbiota and host; collection and transport of specimens, processing of clinical specimens for microbiological examination. b. **Human microbiota in health: functions, microbe-host interaction, health benefits:** Skin microbiota, Gut microbiota, Normal microbiota of oral cavity, Normal microbiota of genitourinary tract. c. **Human microbiota in disease** i. **Human microbiota and infectious disease:** Opportunistic infections; Nosocomial infections; bacterial Infections: Gastroenteric (*Clostridium difficile*; *Helicobacter pylori*; *E. coli*); Skin *(Staphylococcal)*; Respiratory (*Streptococcal*, *Pneumococcal, tuberculosis*); Urogenital tract (UTIs, Bacterial vaginosis); Oral cavity (Dental caries, Periodontitis). ii. **Human microbiota and metabolic disorders:** Irritable bowel disease; Obesity; Type 2 diabetes mellitus; Allergic diseases; Liver diseases.	12

	iii. **Secondary infections:** Infections associated with HIV; Influenza.	
	3. Fungal and parasitic infections **a. Fungal infections/mycoses:** Cutaneous, Sub-cutaneous, systemic and opportunistic mycoses **b. Parasitic infectious:** i. Protozoan infections: Malaria, Amoebiasis ii. Helminthic infections: Ascariasis	5
	4. **Viral infections:** HIV, Influenza, Poliomyelitis, Dengue fever, Chikungunya, Hepatitis, Rabies, Coronavirus disease (COVID-19)	4
	5. **Antimicrobial agents and drug resistance:** a. Classification, mechanism of action of antibacterial agents; antifungal agents; antiviral agents and their resistance b. Antibiotic sensitivity tests and its medical importance	6
	Food Biochemistry **6. Food Spoilage and Food Preservation** **a.** Forms of food spoilage: physical, chemical, microbiological parameters. b. Factors affecting the growth and survival of microorganisms in foods: Intrinsic and extrinsic factors c. Predictive food spoilage microbiology of milk, meat, poultry, vegetables and fruits, grains and legumes. d. Food preservation technologies: Traditional methods of food preservation, Heat processing, low temperature storage, control of water activity, irradiation, high pressure processing, modified atmospheres, preservatives (chemicals, natural organic molecules (nisin) and enzymes).	12
	7. Vitamins and minerals in health a. Fat soluble vitamins: physiological role, deficiency disorders, toxicity. b. Water soluble vitamins: physiological role, deficiency disorders, toxicity. c. Mineral metabolism, physiologic role and deficiency disorders: calcium, iron, magnesium, sodium, zinc, manganese, potassium, phosphorus, sulphur and chlorine.	10
	8. Quality control and Quality Assurance in Food industries a. Microbiological examination of food, air and water in industries. b. Plant sanitation	8

	c. Hazard analysis and critical control point concept d. Good lab practices (GLP) Good Manufacturing Practice (GMP) and Quality Systems in the food industry**.**	
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. Tortora, G. J., Funke, B. R., Case, C. L., Microbiology: An Introduction., Pearson Benjamin Cummings publishers; 2010, 10th Edition. 2. Willey, J., Sandman, K., Wood, D.; Prescott's Microbiology., Mc Graw Hill., 2020, 11th Edition. 3. Harvey, R. A., Cornelissen, C. N., Fisher, B. D., Lippincott's Illustrated review: Microbiology., Lippincott's William and Wilkins; 2007, 3rd Edition. 4. Chauhan, N. S. Introductory Chapter: Human and Microbes in Health and Diseases. In *Role of Microbes in Human Health and Diseases*. IntechOpen., 2019. 5. Feng, Q., Chen, W. D., & Wang, Y. D. (2018). Gut microbiota: an integral moderator in health and disease. *Frontiers in microbiology*, *9*, 151. 6. Frazier, W. C &Westhoff, C.W. Food Microbiology. Graw-Hill Companies, Inc., New York (2017), 5th edition. 7. Hayes, P. R. Food Microbiology and Hygiene. Springer, 1995, 2nd edition. 8. Kniel, K. E., Montville, T. J., Matthews, K. R, Food Microbiology., ASM Press, NW Washington, USA., 2017, 4th edition 9. Jay, J. M., Loessner, M.J., Golden, D.A., Modern Food Microbiology. Springer Science, New York, 2005, 7th edition 10. Adams, M. R. & Moss, M. O. Food Microbiology. Royal Society of Chemistry, 2015, 4th edition 11. Mudambi, R. Sumathi, Rajagpal M.V, Fundamentals of Food, Nutrition and diet therapy, New age International Publishers, 1983, 6th edition.	
Course Outcomes:	1. Students will be able to explain the significance of normal microbiota and the biochemistry of infectious diseases in the human body. 2. Students will be able to explain the importance of antimicrobial agents in antibiotic therapy. 3. They will be able to apply the concepts of food spoilage and food preservation in maintaining food safety. 4. The student will be able to implement the Good Laboratory Practices and Good Manufacturing Practices used in industries to maintain food hygiene.	

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-623 **Title of the Course: Drug metabolism and Pharmaceutics**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have studied natural and life sciences at M.Sc Part I Level	
Course Objectives:	1. To introduce concepts of drug administration, distribution, metabolism and excretion. 2. To introduce the students to pharmacopoeia, and types of drug formulations. 3. To acquaint the students with GMP and quality control practices in a pharmaceutical set-up.	
Content:		**No of hours**
	1. Drugs Absorption and distribution in human body: a. Definition and types of drugs (therapeutic, drugs of abuse, poisons). b. Introduction to pharmacokinetics and pharmacodynamics. c. Routes of drug administration, introduction to absorption, distribution, metabolism, and excretion (ADME) of drug. d. Absorption and distribution of drug through organ /tissue. e. Factors affecting drug distribution: Physicochemical properties of drugs, organ/tissue size, blood flow to the organ, physiological barriers to the distribution of drugs, drug binding blood/ tissue/ macromolecules. f. Protein/tissue binding of drugs – factors affecting protein binding of drugs, significance and kinetics, tissue binding of drugs.	6
	2. Drug Metabolism a. Biotransformation of drugs and factors affecting biotransformation. Organs of drug metabolism: hepatic and extrahepatic metabolism. b. Mechanisms of drug metabolism – inactivation, bioactivation, reactive intermediates. c. Phase 1 reactions - CYP-Catalyzed: Hydroxylation (Primarily at C, N, some at S), Dealkylation (N- and O-dealkylation), Deamination, Epoxidation, Reduction. Non-CYP-Catalyzed: Oxidation (Alcohol and Aldehyde Dehydrogenase, Flavin-Containing Monooxygenase, Monoamine Oxidase), Reductase (Quinone Reductase), Hydrolysis (Esterases, Amidases, Epoxide	7

	Hydrolase). d. Phase 2 reactions -Glucuronidation, Sulfation, Acetylation, Glycine conjugation (minor), Glutathione conjugation (toxic substances). e. Significance of drug metabolism (paracetamol/aspirin/ ibuprofen/ antibiotics).	
	3. Excretion of drugs a. Renal excretion, factors affecting renal excretion. b. Non renal routes of excretion, factors affecting excretion and enterohepatic circulation.	2
	4. Posology a. Determination of doses; dose response relationship, dosage form design, biopharmaceutical consideration. b. Drug antagonism and drug–drug interaction	2
	5. Drug Extraction a. Solvents used in extraction of drugs, processes used for extraction (infusion, decoction, maceration, percolation, hot extraction). b. Water as a universal pharmaceutical vehicle.	5
	6. Types of formulations: a. Tablets: advantages of tablets; types of tablets: effervescent, lozenges, chewable, buccal and sublingual, dispersible, orodispersible, soluble; excipients in tableting, coating in tablets. b. Granulation: methods and equipment, direct compression. c. Sustained release: Delayed absorption and/or a mixture of slow- and fast-release particles to produce rapid and sustained absorption in the same dose. d. Capsules: hard gelatin and soft gelatin capsules-differences and composition, advantages and limitations, Excipients in capsule. e. Liquids and Gels: Types of liquid formulations, excipients including solubilizers, stabilizers, buffers, tonicity modifiers, bulking agents, viscosity enhancers/reducers, surfactants, chelating agents and adjuvants, hydrophilic-lipophilic balance (HLB) values. f. Parenterals: Intravenous, subcutaneous, intramuscular or intra articular administration, stored in liquid form, or in lyophilized form if unstable. g. Topical: Cream, ointment, gel, paste, powder.	15
	7. Quality assurance/ Quality control a. Introduction to GLP, GMP and SOPs Raw material analysis (RMA), Quality control of pharmaceutical excipients.	15

	b. Packaging material testing (PMT): Permeability of plastic; testing of foil, bottles, carrions. Limit tests – chloride, sulphate, arsenic, lead, iron, nitrate, alkali and alkaline earth metals Limits of insoluble matter, soluble matter, non-volatile matter, volatile matter, residue on ignition and ash value. c. Sources of contamination in pharmaceutical compounds (as per Pharmacopoeia). d. Physico-chemical and microbiological analyses of formulations. e. Types of errors, selection of sample, precision and accuracy.	
	8. Drug Stability a. Solid state, solution phase physical stability testing, Stability testing general protocol, climatic zones, reference to regulatory requirements (ICH guidelines). b. Kinetic principles applied for stability evaluation and their applications in predicting shelf life, accelerated stability study and shelf life assignment. c. Forced degradation studies.	5
	9. Research and Development a. Introduction to drug design b. Drug discovery and development c. Clinical trials.	3
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. Brunton, L. L., Hilal-Dandan, R., Knollmann, B. C.; Goodman & Gilman's: The Pharmacological Basis of Therapeutics, McGrawHill Education, 2018, 13th Edition. 2. Mahato R. I., Narang A. S., Pharmaceutical Dosage Forms and Drug Delivery: Revised and Expanded, CRC Press, 2017, 3rd Edition. 3. Aulton, M. E., Pharmaceutics: The Science of Dosage Form Design, Churchill Livingstone; 1988, 7th edition. 4. Aulton, M. E., Taylor, K.; Aulton's Pharmaceutics: The Design and Manufacture of Medicines, Elsevier, 2017, 5th Edition. 5. Allen, L., Popovich, N. G., Ansel, H.; Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems, Lippincott Willimas & Wilkins, 2018, 11th Edition	
Course Outcomes:	1. Students will be able to explain the basic pathways of drug distribution, metabolism and excretion in the body. 2. Students will be able to illustrate the biotransformation mechanisms of drugs involving enzymes in the human body. 3. Students will be able to categorize different types of drug	

	formulations and their contents. 4. They will be able to implement quality assurance and quality control procedures for drug formulations.

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-624 **Title of the Course: Bioprospecting and Bioremediation**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students should have studied natural and life sciences at M.Sc Part I Level	
Course Objectives:	1. To introduce the concept of bioprospecting of bioactive compounds from plant and microbial sources. 2. To impart knowledge on purification and characterization of novel metabolites from biological sources using analytical techniques. 3. To develop concepts in environmental pollution and role of microorganisms in biogeochemical cycles and bioremediation of pollutants	
Content:	**1. Sources and Sampling of potential microbes and plants sources** **a. Sources: microbes and plants** i. Marine and other coastal ecosystems: Water and sediment samples, microorganisms from mangroves, sand dunes and salterns. ii. Terrestrial: Forest/Ghats iii. Microbes in Extreme environments: thermophilic, psychrophilic, halophilic, alkaliphilic, barophilic **b. Sampling microorganisms** i. Niskin water sampler ii. Van Veen Grab sediment sampler **c. Aseptic collection of samples** i. Sampling of plants: Selection criteria: Type, physical condition, stage of growth, plant part. Sample treatment: surface sterilization, excision of desired plant component, extraction.	**No of hours 6**
	2. Industrially and medically important biomolecules from plants and microorganisms: Screening, detection, purification and characterization using analytical tools a. Enzymes: extremozymes; food additives/ quality enhancers, medicine, antioxidants and antitumor agents b. Pigments: food colorants, fabric dyes c. Biocontrol agents:herbicides, pesticides d. Nanoparticles: medicine, drug carriers. e. Biofuels: microbially produced; plant based f. Optical and electronic devices: archaeal metabolites (bacteriorhodopsin and cell wall S-layer as membrane	**24**

	for ultrafiltration) g. Biopolymers – biodegradable plastics: PHAs, blended plastic polymers, EPS, biosurfactants and bioemulsifiers h. Plant growth promoters- gibberellins, auxins, cytokinins i. Pharmaceuticals: Antimicrobials, Antitumour agents, drug carriers. j. Nutraceuticals: PUFAs, β-carotenes, antioxidants k. Cosmeceuticals: humectants (polyols). l. Drugs from Sea	
	3. Pollutants in the environment and their impact: **a. Environment and pollutants** i. Classification of pollutants ii. Toxicity, synergistic or antagonistic action. iii. Eco-toxicology: concept of permissible limits, ED50 & LD50 iv. Acute and chronic exposures; biochemical effects and genotoxicity. **b. Significant environmental pollutants: source, effect and impact** i. Soil Xenobiotics ii. Agricultural chemicals iii. Pesticides iv. lead and other heavy metals v. Marine pollutants **c. Monitoring of pollution** i. Using indicator microorganisms ii. Biosensors: genetically modified organisms and enzymes **d. Significant environmental monitoring parameters** i. Dissolved oxygen ii. Biochemical Oxygen Demand iii. Chemical Oxygen demand. iv. Environment protection regulations, impact assessment and standards. v. Environmental pollutants , improper waste disposal	**10**
	4. Remediation of waste a. Treatment of waste: Concepts of Reuse, Recycle, Recovery. b. Introduction to waste treatment i. Wastewater/sewage treatment ii. Solid waste management iii. Hospital waste management. c. Biological systems for remediation: plants, bacteria and fungi d. Microbial consortia and related microbial processes	**10**

	i. Enzymatic transformations ii. Co-metabolism iii. Microbial adhesion iv. Biofilms v. Production of extracellular polymers and emulsifiers. e. Other pollutant removal techniques i. Sedimentation ii. Sorption iii. Precipitation iv. Speciation conversion f. Emerging eco-friendly alternatives for chemical industry – Green chemistry and Green Technology	
	5. Biotechnological methods to control pollution a. Bioremediation i. In situ and Ex-situ bioremediation ii. Factors affecting process of bioremediation iii. Methods in determining Biodegradability iv. Use of microbes (bacteria and fungi) bioremediation v. Bioremediation of common environmental pollutant vi. Evaluating Bioremediation b. Biofilters c. Biotransformation d. Phytoremediation e. Biodegradation	**10**
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. S. E. Manahan, Environmental Chemistry. Lewis Publishers, 2000. 2. A. V. Salker, Environmental Chemistry. Narosa Nublishing, 2017. 3. A. De, Environmental Chemistry. New Age International Publishers, 2005. 4. S.M. Khopkar, Environmental Pollution Analysis. New Age International Pvt. Ltd., 2005. 5. S.N. Jogdand, Gene Biotechnology. Himalaya publishing house, 2016. 6. S.N. Jogdand, Advances in Biotechnology. Himalaya publishing house, 2007. 7. A. Verma and A. Singh, Animal Biotechnology Models in Discovery and Translation. Academic press, 2020. 8. S.S.Dara, D.D.Mishra, A text book of Environmental Chemistry and Pollution Control. S. Chand Publishers, 2004. 9. R. Mitchell and J.D. Cu, Environmental Microbiology. Wiley-Blackwell Publication, 2009. 10. J. W. Moore and E. A. Moore, Environmental Chemistry. Academic	

	Press, 1976. 11. E. D. Enger, B.E. Smith, Environmental Science: A study of Interrelationships. WCB Publication-McGraw-Hill Higher Education, 2019. 12. U. Satyanarayana and U. Chakrapani, Biotechnology, Books & Allied (P) Ltd, 2020. 13. A. Altman and P Hasegawa, Plant Biotechnology and Agriculture. Elsevier 2011. 14. D. Clark and N.Pazdernik, Biotechnology. Academic Press cell, 2015. 15. J. Pongracz and M.Keen, Medical Biotechnology. Churchill Livingstone, 2009 16. G. L. Fletcher, and M. L. Rise, Aquaculture Biotechnology. Wiley, 2011. 17. I. Ravi, M. Baunthiyal, and J. Saxena, Advances in Biotechnology. Springer, 2014. 18. S. Bielecki, J.Tramper and J.Polak, Food Biotechnology. Elsevier, 2000. 19. R. Maier, I. Pepper, C. Gerba and T. Gentry, Environmental Microbiology. Academic Press, 2008.
Course Outcomes:	1. Students will be able to explain the basic pathways of drug distribution, metabolism and excretion in the body. 2. Students will be able to 3. Students will be able to categorize different types of drug formulations and their contents. 4. They will be able to implement quality assurance and quality control procedures for drug formulations.

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHI-621 **Title of the Course: Bioinorganic Chemistry**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students have studied chemistry/biochemistry courses at M.Sc. Part-I.	
Course Objectives:	1. To understand the role of inorganic elements especially metal ions in biology. 2. To introduce metallobiolecules, metalloproteins & metalloenymes. 3. To understand the role of small molecule model compounds. 4. To introduce the concept of Biomimetic chemistry.	
Content:		**No of hours**
	1.Essential elements in biology Periodicity of elements, distribution of elements in biosphere, bio-availability, bio-stability, building blocks of the biosphere; carbohydrates, nucleic acids and proteins, biological importance of water, and brief review of the chemistry of biopolymers. Metallobiomolecules: classification, metalloproteins (enzymes), metal activated proteins (enzymes), metal functions in metalloproteins, Principles of coordination chemistry related to bioinorganic research, physical methods in bioinorganic chemistry.	12
	2. Alkali and alkaline earth metals in biology Introduction, biological importance of the alkali and the alkaline earth cations, Cation transport through membranes (ion pumps). Photosynthesis, Hill reaction, Chlorin macrocycle and chlorophyll, Absorption of light by chlorophyll, role of metals in photosynthesis, in vitro photosynthesis.	12
	3. Non-redox metalloenzymes Zinc metalloenzymes like carboxypeptidase, carbonic anhydrase and alcohol dehydrogenase, Bio-functions of zinc enzymes, active site structure and model complexes.	12
	4. Biochemistry of a few transition metals Role of Fe, Mo, Cu and Ni. Oxygen carriers and oxygen transport proteins, iron porphyrins (Haemoglobin and myoglobin). Haemocyanins and Haemerythrins, Synthetic models for oxygen binding haemproteins. Cytochrome C, catalase, peroxidase, and superoxide dismutase, blue copper proteins, vitamin B12 coenzymes, nitrogen fixation and iron-sulfur proteins, biological nitrogen fixation, nitrogenase and dinitrogen complexes, iron-sulfur proteins, synthetic analogues for Fe-S proteins, core extrusion reactions. Metal transport and storage: A brief	12

	review of iron transport. transferrin, ferritin, hemosiderin, siderophores, iron biomineralization	
	5.Biomimetic Inorganic Chemistry Fundamentals of biomimetic chemistry, metal – oxygen intermediates, techniques used to probe the active sites of oxygen carriers, redox chemistry of free molecular dioxygen, spectroscopy of Fe-O-Fe moiety, geometry and electronic structure of coordinated dioxygen, other ligands for biological oxygen carriers, reactions of metal-oxygen compounds, oxygenases, Cytochrome P-450, synthetic procedures of simple ligands, isolation of S-containing amino acid or extraction of chlorophyll from green leaves, recrystallization of carboxylic acids. Non-Heme and heme ligands.	12
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. S. J. Lippard & J. M. Berg, *Principles of Bioinorganic chemistry*, Panima Publishing Corporation 2. I. Britini, H. B. Gray, S. J. Lippard & J. S. Valentine, *Bioiorganic chemistry*, University Science books, Mill Valey, CA, 1994. 3. E. Fenton, *Biocoordination Chemistry*, Oxford Chemistry Printers, 25 Oxford University Press, 1995 4. E. Conn, P.K. Stumpf, G. Bruening & R. H. Doi, *Outlines of Bioinorganic Chemistry*, 5th Ed.; Wiley Eastern, 1983. 5. F.A. Cotton, G. Wilkinson, P.L. Gaus, *Basic Inorganic Chemistry*, 3rd Ed. (Chapter 31); Wiley India, 2007. 6. M. Weller, T. Overton, J. Rourke & F. Armstrong *Inorganic Chemistry*, Int. Ed. (Chapter 25); Oxford University Press, 2018. 7. P Atkins, T Overton, J Rourke, M Weller & F Armstrong, *Shriver & Atkins' Inorganic Chemistry,* 5th Ed. (Chapter 27); Oxford University Press, 2010. 8. J. E. Huheey, E. A. Keiter, R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity,* 5th Ed. (Chapter 19); Addison Wesley Publishing. 9. R. W. Hay, *Bioinorganic chemistry*, Ellis Horwood Chichester, 1984. 10. M.N. Hughes, *The Inorganic Chemistry of Biological processes*, 2nd Ed.; Wiley (Interscience), 1984. 11. R. R. Crichton, *Biological Inorganic Chemistry*, Elsevier, 2012. 12. R. Breslow, *Biomimetic Chemistry: Biology as an Inspiration*, The Journal of Biological Chemistry, vol. 284, no. 3, pp. 1337–1342, 2009. 13.C. Housecroft, A. G. Sharpe, *Inorganic Chemistry*, 4th Ed; Pearson Publishing, 2012.	
Course Outcomes:	1. Students will be in a position to clarify the significance of essential elements in biology. 2. Students will be able to explain the role played by metal ions in vital	

	processes like i) oxygen storage and transport and ii) electron transfer. 3. Students will be able to explain basic concepts in Biomimetic chemistry. 4. The students will be able use different techniques in Bioinorganic Chemistry.

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHA-621 **Title of the Course: Fundamentals of Crystallography**

Number of Credits: 4

Effective from AY: 2022-23

Pre-requisites for the Course:	Students have studied chemistry/biochemistry courses at M.Sc. Part-I.	
Course Objectives:	1. To introduce basic concepts of crystallography. 2. To impart knowledge of single crystal and powder X-ray diffraction methods. 3. To analyse Materials and understand Structure. 4. To familiarize students with various applications of Crystallography.	
Content:		**No of hours**
	1. Basics of Crystallography a. The Crystalline state, symmetry elements. b. Lattices, unit cell, crystallographic directions, planes, point groups and symmetry classes. c. The Laue classes, the seven crystal systems, Bravais lattices, space groups and International Tables. d. Description of crystal structures, unit cell projections and atomic coordinates, unit cell content. e. Ionic crystals, molecules and molecular crystals, protein crystals, physical properties of crystals.	10
	2. Diffraction of X-rays by Crystals: a. Interaction of X-rays with matter. b. Scattering of X-rays by an electron, atom, atomic scattering factor, temperature factor, scattering by molecule or unit cell. c. Diffraction by crystals, structure factor, Bragg's law, the reflection and the limiting spheres, symmetry in reciprocal space, systematic absences, diffraction intensities. d. Experimental methods in X-ray crystallography: X-ray sources, monochromatization, collimation, and focusing of X-rays.	10
	3. Single Crystal X-ray Diffraction: a. Crystals and their properties: crystallization, growing and choosing crystals, microscopic observation b. Data collection techniques for single crystals, diffractometer geometry, measurement of the integrated intensities, data collection with area detectors, c. Data reduction: Lorentz correction, polarization correction, absorption corrections, radiation damage	10

	corrections, relative scaling. d. Solution and refinement of crystal structures: Wilson plot, the heavy atom method, Direct methods, phase determination procedures, figures of merit, e. Completing and refining the structure: difference Fourier method, least-squares method, absolute configuration. f. Introduction to crystallographic software's (e.g. APEX 4, Olex2 etc) and IUCr validation of the data (CIF)	
	Powder X-ray Diffraction: a. Origin of powder diffraction pattern, position, shape, and intensity of powder diffraction peaks. b. Powder diffractometry: beam conditioning, goniometer design, nonambient powder diffractometry. c. Collecting quality powder diffraction data: sample preparation, data acquisition, quality of data, data processing. d. Determination of unit cell: indexing methods. e. Introduction to the Rietveld method. d. Introduction to powder diffraction software's for indexing, unit cell refinement (e.g. Winplotr, UnitCell).	10
	5. Applications of Crystallography: a. Chemistry and Materials science: understanding crystal structures of compounds, alloys, metals, polymers, phase transitions etc. b. Geology, mineralogy, gemology. c. Pharmaceuticals: polymorphs, excipient analysis, active pharmaceutical ingredients. d. Forensics and environmental analysis. e. Nano materials characterization. f. Biomolecules: determination of structures of proteins, nucleic acids and other biological macromolecules. g. Other diffraction techniques: neutron diffraction, thin film, microstructure properties, pair distribution function analysis, etc.	10
	6. Analysis of Materials and Structural Understanding: a. Characterisation of Solids using diffraction techniques. b. Introduction to databases: powder diffraction files, inorganic and organic crystal structure database, protein data bank etc. c. Inspection of crystals/powders with light microscope. d. Visualization of crystal structures using softwares (e.g. Diamond, VESTA). e. Beyond ideal crystals: crystal twins, modulated	10

	structures, quasicrystals	
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings:	1. M. Milanesio, G. Zanotti, G. Gilli, M. Catti, H. Monaco, G. Ferraris, G. Artioli, P. Gilli, D. Viterbo, C. Giacovazzo - *Fundamentals of Crystallography*, 3rd Ed., Oxford University Press, 2015. 2. C. Hammond - *The Basics of Crystallography and Diffraction (International Union of Crystallography Texts on Crystallography)* 4th Ed., Oxford University Press, 2015. 3. R. West, *Solid State Chemistry and Its Applications*, 2nd Ed.; Wiley, 2022. 4. F. Hoffmann, *Introduction to Crystallography*, 1st Ed. Springer, 2020. 5. D. Sherwood, *Crystals, X-rays and Proteins: Comprehensive Protein Crystallography*, 1st Ed. Oxford University Press, 2015. 6. A. Hofmann, S. Clokie, *Wilson and Walkers Principles and Techniques of Biochemistry and Molecular Biology*, 8th Ed.; Cambridge University Press, 2018. 7. V. Pecharsky and P. Zavalij, *Fundamentals of Powder Diffraction and Structural Characterization of Materials*, 2nd Ed.; Springer, 2009. 8. R. Young, *The Rietveld Method*, 1st Ed., Oxford University Press, 1995 9. W. David, K. Shankland, L. McCusker, C. Bärlocher, *Structure Determination from Powder Diffraction Data*, 1st Ed., Oxford University Press, 2006. 10. B. He, *Two-dimensional X-ray Diffraction*, 1st Ed., Wiley, 2009. 11. W. Massa, *Crystal Structure Determination*, 2nd Ed., Springer, 2010. 12. R. Dinnebier, S. Billinge, *Powder Diffraction: Theory and Practice*, 1st Ed., Royal Society of Chemistry, 2008.	
Course Outcomes:	1. Students will acquire fundamental concepts of crystallography. 2. Students will gain insights into single crystal and powder X-ray diffraction methods. 3. Students will be able to use X-ray diffraction methods for materials characterization. 4. Students will be able to correlate crystal structure and materials properties	

Name of the Programme: M.Sc. Part-II (Biochemistry)

Course Code: CHB-651 **Title of the Course:** Discipline Specific Dissertation

Number of Credits: 16

Effective from AY: 2022-23

Pre-requisites for the Course:	Students have studied chemistry/biochemistry courses at M.Sc. Part-I.	
Course Objectives:	To develop the skills of preparing and conducting independent research.	
Content:	As per OA-35	**No of hours** 480
Pedagogy:	Dissertation carried out individually by each student throughout the academic year.	
References/ Readings:	As required for the development of review and methodology	
Course Outcomes:	Students will be able to understand and apply the tools and techniques of Biochemistry in conducting independent research.	