

KURUKSHETRA UNIVERSITY, KURUSKHETRA
(‘A+’ Grade NAAC Accredited)

DEPARTMENT OF BIOCHEMISTRY
Curriculum for M. Sc. Biochemistry (Semester System)
Under CBCS-LOCF Scheme of Examination (w.e.f. 2023-2024) in phased manner

Semester – I

Paper code	Title of Paper	Type of paper	Hours/ week	Credits	Internal Assessment	External Marks	Total Marks	Duration of Exam (Hrs)
BCH-101	Structure and Function of Biomolecules	Core	4	4	20	80	100	3
BCH-102	Cell Biology and Human Physiology	Core	4	4	20	80	100	3
BCH-103	Proteins and Proteomics	Core	4	4	20	80	100	3
BCH-104	Bioenergetics and Metabolism	Core	4	4	20	80	100	3
BCH-105	Practical-1 (Based on papers BCH-101 and BCH-102)	Core	8	4	20	80	100	8
BCH-106	Practical-2 (Based on papers BCH-103 and BCH-104)	Core	8	4	20	80	100	8
Total				24			600	

Semester –II

Paper code	Title of Paper	Type of paper	Hours / week	Credits	Internal Assessment	External Marks	Total Marks	Duration of Exam (Hrs)
BCH-201	Industrial Biochemistry	Core	4	4	20	80	100	3
BCH-202A	Clinical Biochemistry	Elective	4	4	20	80	100	3
BCH-202B	Nutritional Biochemistry	Elective	4	4	20	80	100	3
BCH-203	Enzymology	Core	4	4	20	80	100	3
BCH-204	Molecular Biology -I	Core	4	4	20	80	100	3
BCH-205	Food Biochemistry	Open Elective	2	2	10	40	50	3
BCH-206	Practical-3 (Based on papers BCH-201 and BCH-202A & B)	Core	8	4	20	80	100	8

BCH-207	Practical-4 (Based on papers BCH-203 and BCH- 204)	Core	8	4	20	80	100	8
Total				26			650	

***The students entering in 3rd semester of their programs (PG) w.e.f. 2023-24 onwards will be allowed to opt for summer/Industrial training (with a recognized industry research laboratory/company) in lieu of open elective paper (BCH-306) for minimum 6 weeks duration and can be done only during summer vacation falling in the period intervening between 2nd and 3rd Semester.**

Semester –III

Paper code	Title of Paper	Type of paper	Hour s/ week	credits	Internal Assessment	External Marks	Total Marks	Duration of Exam (Hrs)
BCH-301	Molecular Biology -II	Core	4	4	20	80	100	3
BCH-302	Immunology	Core	4	4	20	80	100	3
BCH-303	Plant Biochemistry	Core	4	4	20	80	100	3
BCH-304	General Microbiology	Core	4	4	20	80	100	3
BCH-305	Seminar	Core	1	1	-	-	50	
BCH-306	Clinical Diagnostics in Health and Disease	Open Elective	2	2	10	40	50	3
BCH-306A*	Summer/industrial training	Presentation and Project Report				50	50	
BCH-307	Practical-5 (Based on papers BCH-301 and BCH- 302)	Core	8	4	20	80	100	8
BCH-308	Practical-6 (Based on papers BCH-303 and BCH- 304)	Core	8	4	20	80	100	8
Total				27			700	

Semester –IV

Paper code	Title of Paper	Type of paper	Hours/ week	Credits	Internal Assessment	External Marks	Total Marks	Duration of Exam (Hrs)
BCH-401	Biotechniques	Core	4	4	20	80	100	3
BCH-402	Genetic Engineering	Core	4	4	20	80	100	3
BCH-403	Biostatistics and Bioinformatics	Core	4	4	20	80	100	3
BCH-404A	Pharmacovigilance and Clinical Trials	Elective	4	4	20	80	100	3
BCH-404B	Genetics and Evolution	Elective	4	4	20	80	100	3
BCH-405	Practical-7 (Based on papers BCH-401 and BCH-402)	Core	8	4	20	80	100	8
BCH-406	Practical-8 (Based on papers BCH-403 and BCH-404A & B)	Core	8	4	20	80	100	8
Total				24			600	
Grand Total (Semester I-IV)							2550	

Program Outcomes (POs)

PO1: To acquaint students with recent knowledge and techniques in recent basic and applied biological sciences.

PO2: To develop understanding of organismal, cellular, biochemical and environmental basis of life.

PO3: To develop insight into ethical implication of biological research for environmental protection and good laboratory practices and biosafety.

PO4: To develop problem solving innovative thinking and robust communication and writing skills in youth with reference to biological, environmental and nutritional sciences.

PO5: To understand application of biotic materials in health, medicine, food security for human well-being and sustainable development.

PO6: To impart practical and project based vocational training for preparing youth for a career in research and entrepreneurship in the field of life sciences for self-reliance.

Program Specific Outcomes (PSOs)

PSO1: An ability to acquire in-depth theoretical and practical knowledge of Biochemistry in the broad range of fields including Structure and Function of Biomolecules, Cell Biology and Human Physiology, Proteins and Proteomics, Intermediary Metabolism, Industrial Biochemistry, Enzymology, Plant Biochemistry, Immunology, Molecular Biology, General Microbiology, Clinical Biochemistry, Nutritional Biochemistry, Biotechniques, Genetic Engineering, Biostatistics and Bioinformatics,

Pharmacovigilance and Clinical Trials, and Genetics and Evolution.

PSO2: Diligently learn and link the applicability of the theoretical and practical knowledge imparted in routine life to the understanding of cellular, molecular, biochemical and metabolic basis of life and understand the role of scientific developments in relation to professional and every day use.

PSO3: Acquire necessary knowledge and skills to appear for competitive exams for higher studies and to undertake a career in research, either in industry or in an academic set up.

PSO4: An ability to work independently, demonstrate scientific writing, possess effective presentation skills to explain various concepts of Biochemistry, ability to formulate research hypothesis and contribute to team work and participate constructively in classroom discussions.

Core
M. Sc. (Biochemistry) Semester- I
Paper: BCH-101
Structure and Function of Biomolecules

Total Marks: 100

External Marks: 80

Internal Assessment: 20

Time allowed: 3 hrs

Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions and covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. The candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To introduce the student to the structure and function of biomolecules and understand the chemical principles in life processes.
- To familiarize student about the hormones and disorders associated with the over- or under-production of hormones.

Course outcomes:

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

- 101.1 Understand an overview of importance of biomolecules starting from the simplest molecule, water. Understand the structure and the role of carbohydrate.
- 101.2 Understand the structure and the role of amino acids, and nucleotides and their cellular functions in physiology.
- 101.3 Understand the structure and the role of lipids.
- 101.4 Know integrated understanding of hormones and their related disorders.

SECTION - A

Water and Carbohydrates: Water and its physicochemical properties; Classification of carbohydrates; Occurrence, characteristics, structure and functions of monosaccharides, disaccharides, oligosaccharides and polysaccharides; structure and conformation of sugars; monosaccharides: stereoisomerism and optical isomerism; chemical reactions of the functional groups; sugar derivatives; Glycoproteins; peptidoglycan, proteoglycan, N-linked and O-linked glycoproteins bacterial cell wall polysaccharides; blood group polysaccharides; glycobiology, glycomics

SECTION - B

Amino acids and nucleotides: Nature of chemical bond, Covalent Bond, Coordinate bond, ionic bond, Hydrogen bond, Vanderwaal's interactions, hydrophobic interactions, Disulfide bond; Structure, nomenclature, classification, acid-base properties of amino acids, chemical reactions of amino acids; stereoisomerism and optical properties of amino acids; non-natural amino acids, Functions of amino acids; DNA/RNA bases, Nucleosides, Nucleotides, oligonucleotides; Structure and properties of purines and pyrimidine bases; structure and functions of nucleotides.

SECTION - C

Lipids: Classification of lipids; structures, nomenclature and properties of fatty acids; structure, properties and functions of acylglycerols, plasmalogens, phospholipids, sphingolipids, glycolipids, steroids, prostaglandins and eicosanoids, bile acids lipoamino acids; chemical composition and biological role of lipoproteins; structure and functions of fat soluble vitamins.

SECTION - D

Hormones: General characteristics, classification, chemistry, functions and mechanism of action of thyroid, parathyroid, adrenal, pancreatic, gastric and reproductive hormones; hypothalamus and pituitary; detection of hormones; hormone replacement therapy; pheromones. Regulation of growth hormones, ADH, oxytocin, thyroid hormones, mineralocorticoid, glucocorticoid, insulin, glucagon, parathyroid hormone, and male and female reproductive hormones.

Suggested reading:

1. Lehninger: Principles of Biochemistry, 8th edition, by David L. Nelson and M M Cox (2021), Macmillan / Worth publishers/ W H Freeman and Company.
2. Biochemistry (2004) by J David Rawn, Panima Publishing Corporation, New Delhi.
3. Biochemistry, 6th edition, by R H Garrett and C M Grisham (2016), Saunders College Publishing, New York.
4. Biochemistry, 7th edition, by Jeremy M. Berg (2015), W H Freeman and Co., New York.
5. Fundamentals of Biochemistry, 6nd ed., by Donald Voet, Judith G. Voet and Charlotte W Pratt (2020), John Wiley and Sons, INC.
6. Textbook of Medical Physiology, 14th ed., A C Guyton and J E Hall (2020) Elsevier.
7. Biochemistry, 6th ed. Zubay, G., (2016). Wm.C Brown Publishers, Saunders and Company, Philadelphia.
8. Biochemistry by U. Satyanarayana (2019). Books and allied (P) Ltd.

Teaching Learning Process

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO mapping matrix for BCH 101 (Structure and Functions of Biomolecules)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH101.1	3	3	-	2	-	2
101.2	3	3	-	2	-	2
101.3	3	3	-	2	-	2
101.4	3	3	-	2	-	2
Average	3	3	-	2	-	2

CO-PSO mapping matrix for BCH 101 (Structure and Functions of Biomolecules)

COs	PSO1	PSO2	PSO3	PSO4
BCH 101.1	3	3	3	3
101.2	3	3	3	3
101.3	3	3	3	3
101.4	3	3	3	3
Average	3	3	3	3

Core
M.Sc. (Biochemistry) Semester - I
Paper: BCH – 102
Cell Biology and Human Physiology

Total Marks: 100

External Marks: 80

Internal Assessment: 20

Time allowed: 3 hrs

Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To provide students with a comprehensive understanding of molecular biology of cells and the key techniques involved in cell biology.
- To understand the concept of biosignaling
- To explain basic physiology of various systems and regulation of body's organ systems.

Course outcomes:

After studying this course, students will be able to:

102.1 Understand the detailed information regarding bio-membranes and membrane transport.

102.2 Understand the concept of cytoskeleton. Explain the communications of cells with other cells and to the environment.

102.3 Understand the basic mechanisms of secretion and stimulation of alimentary tract glands and describe the physiology of digestion in humans. Gain knowledge about physiology of respiration

102.4 Have an overview of excretory system and neurotransmission.

SECTION-A

Plasma membrane: An overview of membrane functions; Brief history of studies on plasma membrane structure, chemical composition of membranes: membrane lipids, membrane carbohydrates and membrane proteins, Glycocalyx, membrane lipids and membrane fluidity, the dynamic nature of the plasma membrane, methods of introducing a membrane-impairment substance into a cell.

Membrane transport of small molecules:

Principles of membrane transport, Passive diffusion, Facilitated diffusion and carrier proteins, ion channels, active transport driven by ATP hydrolysis and by ion gradients. Cells as experimental models.

SECTION- B

Cytoskeleton: Microfilaments: structure and organization, muscle contractility; Microtubules: structure and dynamic organization of microtubules, Microtubule organizing centers: centrosomes and basal bodies; Microtubule motor proteins; Cilia and flagella: structure and functions, Intermediate filaments: intermediate filament proteins; assembly, intracellular organization and functions of intermediate filaments

Cellular interactions: Extracellular matrix: matrix structural proteins, matrix polysaccharides, matrix adhesion proteins, Interactions of cells with extracellular materials: integrins, focal adhesions and hemidesmosomes; Interactions of cells with other cells: Adhesion junctions, Tight junctions, Gap junctions and Plasmodesmata.

The Biosignaling: General features of signal transduction, G protein-coupled receptors and Second messengers (cAMP, diacyl glycerol, inositol triphosphate and Ca²⁺ ions), receptor tyrosine kinases.

SECTION – C

Gastrointestinal Physiology: Secretory functions of the alimentary tract: General principles of alimentary tract secretion; Basic mechanism of stimulation of alimentary tract glands; Basic mechanism of secretion by glandular cells; Lubricating and protective properties of mucus and importance of mucus in gastrointestinal tract; Composition, function and regulation of saliva, gastric, pancreatic, intestinal and bile secretions.

Respiration: Components of respiratory system and their functions; transfer of blood gases- O₂ and CO₂; Bohr effect; role of chloride ions in oxygen transport; effect of 2,3-BPG on O₂ affinity of Hb; Clinical importance of 2,3-BPG. Acid base balance; Role of blood buffers; respiratory and renal mechanism in the maintenance of blood pH.

SECTION – D

Excretory System: Structure of nephron; formation of urine; tubular re-absorption of glucose, water and electrolytes; tubular secretion; regulation of water and electrolyte balance; role of kidneys and hormones in their maintenance.

General principles of nervous system: Structure of a neuron, resting potential, action potential, propagation of action potentials as an impulse; types of synapses; role of Ca⁺² in release of neurotransmitter from pre-synaptic membrane; function of receptor proteins and secondary messenger on the postsynaptic neuron; Characteristics of some important neurotransmitters (Dopamine, GABA, Glutamate, Acetylcholine, Serotonin, NO).

Suggested readings:

1. Cell and Molecular Biology-Conceptsand experiments, 7thed. (2008) Gerald Carp-Wiley & Sons
2. The Cell: A Molecular Approach, G.M. Cooper R.E. Hausman (2007), 6thed. ASM Press
3. Cell and Molecular Biology, 8thed.E.D.P. DeRobertis & E.M.F. DeRobertis (2001), Lippincott Williams and Wilkins
4. Molecular Biology of the Cell (2008) 5thed. Alberts *et al.* Garland Science, Taylorand Francis Group
5. Molecular Cell Biology (2020) 9thed. Lodish *et al.*, W.H. Freeman & Company
6. Text book of Medical Physiology, 14th edition, A C Guyton & J E Hall. (2020) Elsevier.
7. Human physiology, 12th edition by Stuart Ira Fox (2011) McGraw-Hill Education (ISE editions)
8. Tortora's Principles of Anatomy & Physiology, 15th edition by Gerard J. Tortora & Bryan H. Derrickson (2017) John Wiley & Sons
9. Vander's Human physiology, 16th edition by Hershel Raff, Eric Widmaier & Kevin Strang (2020) McGraw-Hill Education
10. Lehninger: Principles of Biochemistry, 8th edition, by David L. Nelson and M.M. Cox (2021) Maxmillan/ Worth publishers. Freeman& Co. New York.

Teaching Learning Process

- Teaching is supported by Classroom Lectures, Powerpoint presentations and related videos.
- Oral or written assignments are assigned.
- Knowledge of the students is tested through surprise tests and internal assessments.

CO-PO Mapping Matrix for the course BCH-102 (Cell Biology and Human Physiology)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH-102.1	3	3	-	1	3	2
BCH-102.2	3	3	-	1	3	2
BCH-102.3	3	3	-	1	3	2
BCH-102.4	3	3	-	2	3	3
Average	3	3	-	1.25	3	2.25

CO-PSO Mapping Matrix for the course BCH-102 (Cell Biology and Human Physiology)

COs	PSO1	PSO2	PSO3	PSO4
BCH-102.1	3	3	3	3
BCH-102.2	3	3	3	3
BCH-102.3	3	3	3	3
BCH-102.4	3	3	3	3
Average	3	3	3	3

Core
M.Sc. (Biochemistry) Semester- I
Paper: BCH – 103
Proteins and Proteomics

Total Marks: 100

External Marks: 80

Internal Assessment: 20

Time allowed: 3 hrs

Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To understand proteins, their structure, conformation and dynamics, protein folding, and protein purification and their separation.
- To aware about the various aspects of mass spectrometry including MALDI-TOF, ESI-MS, MS/MS and X-ray crystallography for prediction of three-dimensional structure of protein.

Course outcomes:

After studying this course, students will be able to:

103.1 Understand the structure, conformation and folding of proteins.

103.2 Learn various methods of protein purification and their separation

103.3 Know the various aspects of mass spectrometry and X-ray crystallography

103.4 Apply the mass spectrometry and X-ray crystallography for prediction of the three-dimensional structure of proteins.

SECTION - A

Primary structure of proteins: Hierarchy of protein structure; Peptides, Proteins, Dihedral angles, psi and phi, omega, Ramachandran plot; **Secondary and tertiary structure of proteins:** Alpha helix and beta sheets; 3₁₀-helix, 3.613-helix, 4.416-helix, Collagen helix and other types of helical structures; Super secondary structures; Amino acid sequence and three dimensional structure; Domains; Forces stabilizing the secondary and tertiary structure. Artificial peptide synthesis and applications, Structure and function of some biologically important polypeptides. Determination of primary structure of protein – determination of N and C-terminal residue; Determination of amino acid composition of protein and determination of sulfhydryl groups; location of disulfide bonds;

SECTION - B

Sequencing, protein folding and denaturation: Protein sequencing; Sequenators; Quaternary structure of protein; Structure and function of hemoglobin and cytochrome c; Denaturation and renaturation of proteins; Characteristics of molten globule state; Principle of protein folding, Proteins involved in folding; Models of protein folding; Chaperones and Lavinthal paradox; Protein conformation and diseases.

SECTION - C

Protein purification and separation techniques: Protein purification; criteria of purity, and fold purification; Ion-exchange, gel-filtration and affinity chromatography techniques; High performance liquid chromatography (HPLC); Iso-electric focusing (IEF); Native-PAGE and SDS-PAGE; Detection and quantification of proteins in gels; Recovery of proteins from gels.

SECTION - D

Proteomics: Overview and tools; Two-dimensional PAGE; Protein spot detection; iTRAQ, Mass spectrometry: matrix assisted laser desorption ionization MS, Electrospray ionization MS, and tandem MS for protein identification; Identification of protein-protein interactions; Protein complexes; X-ray crystallography; Transmembrane domains; Functional proteomics; Application of proteome analysis.

Suggested readings:

1. Biochemistry, 7th edition, by Jeremy M. Berg (2015), W H Freeman and Co., New York.
2. Fundamentals of Biochemistry, 6th ed., by Donald Voet, Judith G Voet and Charlotte W Pratt, John Wiley and Sons, INC.
3. Principles of Peptide synthesis (2012), 2nd ed., M Bodansky, Springer - Verlag Berlin, Heidelberg.
4. Principles of Proteomics (2004), R M Twyman, 7th edition, BIOS Scientific Publishers.
5. Handbook of Proteomic Method (2010), P Michael Conn, Humana Press, Totowa, New Jersey, USA.

CO-PO mapping matrix for BCH 103 (Proteins and Proteomics)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 103.1	3	3	--	--	-	--
103.2	3	1	1	3	--	1
103.3	3	--	2	3	--	2
103.4	2	--	2	2	--	1
Average	2.75	1.0	1.25	2.0	--	1.0

CO-PSO mapping matrix for BCH 103 (Proteins and Proteomics)

COs	PSO1	PSO2	PSO3	PSO4
BCH 103.1	3	2	2	2
103.2	2	3	3	2
103.3	3	3	3	3
103.4	2	3	2	2
Average	2.5	2.75	2.5	2.25

Core
M.Sc. (Biochemistry) Semester- I
Paper: BCH – 104
Bioenergetics and Metabolism

Total Marks: 100

External Marks: 80

Internal Assessment: 20

Time allowed: 3 hrs

Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To provide students a comprehensive understanding of energetics and metabolic pathways of carbohydrate, nucleotides, lipids and amino acids metabolism.

Course outcomes:

After studying this course, students will be able to:

- 104.1 Understand the concept of high energy compounds and redox reactions and its application to the study of metabolism. Describe various anabolic and catabolic pathways like glycolysis, Krebs's cycle, HMP shunt, glycogen metabolism etc. and their regulation for better understanding of physiology and therapeutic applications.
- 104.2 Understand the pathways involved in the catabolism and biosynthesis of nucleotides.
- 104.3 Comprehend reactions and regulation of pathways involved in the metabolism of lipids.
- 104.4 Understand the pathways involved in the catabolism and biosynthesis of amino acids

SECTION – A

Coupled reactions; High-energy compounds. Biological oxidation: Oxidation & reduction; Oxidation-reduction half reactions; Enzymes involved in oxidation and reduction (oxidases, dehydrogenases, hydroperoxidases and oxygenases). Introduction to Metabolism and Experimental approaches for studying metabolism.

Carbohydrate Metabolism: Reactions, energetics and regulation of glycolysis; Feeder pathways for glycolysis; Fate of pyruvate under aerobic and anaerobic conditions; Pasteur effect; Pyruvate dehydrogenase complex and its regulation; Reactions, regulation and amphibolic nature of TCA Cycle; Anaplerotic reactions; Glyoxalate cycle; Pentose Phosphate Pathway; Gluconeogenesis; Cori cycle; Biosynthesis of lactose and sucrose; Glycogenesis and Glycogenolysis; Control of glycogen metabolism;

SECTION – B

Nucleotide metabolism: *De novo* biosynthesis and regulation of purine and pyrimidine nucleotides; Salvage pathways of purines and pyrimidines; Ribonucleotide reductase and formation of deoxyribonucleotides (dNTPs) from ribonucleotides (NTPs); Catabolism of purine and pyrimidine nucleotides; Chemotherapeutic agents as inhibitors of enzymes in nucleotide biosynthetic pathways; Biosynthesis of nicotinamide coenzymes, flavin coenzymes and coenzyme A.

SECTION – C

Lipid Metabolism: Mobilization and hydrolysis of triacylglycerols; Fatty acid oxidation: Franz Knoop's experiment; β -oxidation of saturated, unsaturated and odd-chain fatty acids; Peroxisomal β -oxidation; Minor pathways of fatty acid oxidation (α - and ω - oxidations); Formation and utilization of Ketone

bodies; Biosynthesis of saturated fatty acids; Elongation and desaturation of fatty acids; Biosynthesis of triacylglycerols; Regulation of fatty acid metabolism; Cholesterol biosynthesis and its regulation; Biosynthesis of glycerophospholipids and sphingolipids; Breakdown of sphingolipids by lysosomal enzymes; Formation of prostaglandins, prostacyclins, thromboxanes and leukotrienes from arachidonic acid.

SECTION – D

Amino acid degradation: General reactions of amino acid metabolism: Transamination; Oxidative, non-oxidative deamination and decarboxylation reactions; Role of glutamine in ammonia transport; Glucose-Alanine Cycle; Urea Cycle; Metabolic breakdown of individual amino acids (both essential and non-essential)

Amino acid biosynthesis: Biosynthesis of non-essential and essential amino acids; Regulation of amino acid biosynthesis; Amino acids as biosynthetic precursors of phosphocreatine, glutathione, dopamine, non-epinephrin and epinephrin, GABA, histamine, serotonin, polyamines (spermine and spermidine), and indole-3-acetic acid.

Suggested readings:

1. Lehninger: Principles of Biochemistry, 8th edition, by David L. Nelson and M.M. Cox (2021) Maxmillan/ Worth publishers/ W. H. Freeman & Company.
2. Fundamentals of Biochemistry, 6rd edition, by Donald Voet and Judith G Voet (2020) , John Wiley & Sons, NY
3. Biochemistry, 6nd edition, by R.H. Garrett and C. M. Grisham (2016). Saunders College Publishing, NY.
4. Biochemistry, 6th edition, by Jeremy M. Berg (2007). W.H. Freeman & Co., NY.
5. Harper's Biochemistry, 26th edition, by R.K. Murray, P.A. Hayes, D.K. Granner, P.A. Mayes and V. W. Rodwell (2003). Prentice Hall International.
6. Biochemistry, 3rd edition, by C.K. Mathews, K.E. vans Holde and K.G. Ahern (2000). Addison-Wesley Publishing Company.
7. Biochemistry (2004) by J. David Rawn, Panima Publishing Corporation, New Delhi.

Teaching Learning Process

- Teaching is supported by Classroom Lectures, Power point presentations and related videos.
- Oral or written assignments are assigned.
- Knowledge of the students is tested through surprise tests and internal assessments.
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CO-PO Mapping Matrix for the course BCH-104 (Bioenergetics and Metabolism)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH-104.1	3	3	-	2	1	1
104.2	3	3	-	2.5	1	2
104.3	3	3	-	2.5	1	2
104.4	3	3	-	2	1	1
Average	3	3	-	2.25	1	1.5

CO-PSO Mapping Matrix for the course BCH-104 (Bioenergetics and Metabolism)

COs	PSO1	PSO2	PSO3	PSO4
BCH-104.1	3	3	3	2
104.2	3	3	3	2
104.3	3	3	3	2
104.4	3	3	3	2
Average	3	3	3	2

Core
M.Sc. (Biochemistry) Semester - I
Paper: BCH –105
Practical-1 (Based on papers BCH-101 and BCH-102)

Total Marks:100

External Marks: 80

Internal Assessment: 20

Time allowed: 8hrs

Credits: 4

Course outcomes:

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

105.1 Get more acquainted with the basic practical techniques related to various biomolecules and techniques involved in cell biology.

105.2 Standardize and qualitatively & quantitatively estimate various biomolecules including carbohydrates, lipids and proteins in the biological samples.

105.3 Get an insight/awareness about the safe laboratory practices.

105.4 Understand the principle and working of different types of Light microscopy and Electron microscopy and its applications in various fields of research.

List of experiments*

1. To study biochemistry laboratory safety rules and guidelines
2. To perform Biochemical calculation.
3. Standardization of pH meter and Preparation of buffers
4. Qualitative estimation of carbohydrates
5. Qualitative estimation of proteins/amino acids
6. Qualitative estimation of lipids
7. Quantitative estimation of proteins by Lowry's method
8. Quantitative estimation of proteins by Bradford method
9. Quantitative estimation of total sugars
10. Quantitative estimation of reducing sugars by Nelson-Somoyogi's method
11. Solubility test for lipids
12. To detect the presence of glycerol in given sample by acrolein method
13. Characterization of lipids (Acid value, Saponification value and Iodine number)
14. Extraction of lipids from tissues using Soxhlet's apparatus
15. To determine pka of acetic acid/glycine
16. To demonstrate: Light microscopy, Fluorescence microscopy, Confocal microscopy, Electron microscopy (scanning and transmission)

*As per feasibility of practical(s), teacher concerned may conduct additional practical(s) in addition to the present list, which will also be the part of syllabus for evaluation.

CO-PO Mapping Matrix for the course BCH-105(Practical-1)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH-105.1	3	3	-	1	3	3
BCH-105.2	3	3	-	1	3	3
BCH-105.3	3	-	3	-	-	1
BCH-105.4	3	3	-	-	-	3
Average	3	2.25	0.75	0.5	1.5	2.5

CO-PSO Mapping Matrix for the course BCH-105(Practical-1)

COs	PSO1	PSO2	PSO3	PSO4
BCH-105.1	3	3	2	1
BCH-105.2	3	3	2	1
BCH-105.3	3	3	2	1
BCH-105.4	3	3	2	2
Average	3	3	2	1.25

Core
M.Sc. (Biochemistry) Semester - I
Paper: BCH –106
Practical-2 (Based on papers BCH-103 and BCH-104)

Total Marks: 100

External Marks: 80

Internal Assessment: 20

Time allowed: 8hrs

Credits: 4

Course Outcomes:

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

- 106.1 Well acquainted with the titration and spectrophotometric estimation of biomolecules
- 106.2 An understanding of different chromatographic techniques and their application in purifications and separations of biomolecules
- 106.3 Develop skills of using various equipment involved in biomolecules purification and separation
- 106.4 Develop skills in carrying out research projects by employing basic biochemical techniques

List of experiments*

1. Titration of a weak acid using a pH meter
2. Verification of Beer-Lambert's law and determination of absorption coefficients
3. Concentration of a protein sample by ultrafiltration (using stirred cell)
4. Separation of amino acids and carbohydrates in a mixture by Paper chromatography
5. Separation of lipids/amino acids by TLC
6. Purification of an enzyme by ion-exchange chromatography
7. Purification of an enzyme/protein by Affinity chromatography
8. Determination of void volume of a gel filtration column
9. Determination of molecular weight of an enzyme by gel filtration chromatography
10. Separation of proteins by Native PAGE
11. Determination of molecular weight of a protein by SDS-PAGE
12. Demonstration of HPLC, GC and GC-MS
13. Demonstration of LC-MS and ICP
14. Demonstration of Iso-electric focussing
15. Demonstration of 2D-PAGE

*As per feasibility of practical(s), teacher concerned may conduct additional practical(s) in addition to the present list, which will also be the part of syllabus for evaluation.

CO-PO mapping matrix for BCH 106 (Practical-2)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 106.1	3	3	2	2	-	2
106.2	3	3	2	2	-	2
106.3	3	3	2	2	-	2
106.4	3	3	2	2	-	2
Average	3	3	2	2	-	2

CO-PSO mapping matrix for BCH 106 (Practical-2)

COs	PSO1	PSO2	PSO3	PSO4
BCH 106.1	3	3	3	3
106.2	3	3	3	3
106.3	3	3	3	3
106.4	3	3	3	3
Average	3	3	3	3

Core
M.Sc. (Biochemistry) Semester - II
Paper: BCH – 201
Industrial Biochemistry

Total Marks: 100

External Marks: 80

Internal Assessment: 20

Time allowed: 3 hrs

Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To provide students a comprehensive understanding of Industrial Biochemistry.

Course outcomes:

After studying this course, students will be able to:

201.1 Understand the regulatory guidelines of ICH, WHO and USFDA, and laboratory maintenance and management rules and regulations.

201.2 Understand the scope of Industrial Biochemistry. Product development and validation methods

201.3 Understand the scope of clinical and medical diagnostics and pharmaceutical regulatory affairs

201.4 Understand the practice the ethics in research and aware about IPR and bioethics.

SECTION - A

Laboratory Maintenance and Management: Laboratory safety rules and guidelines, safety equipments, Stability testing: ICH, WHO and USFDA guidelines, Concept and significance of Biosafety, Bio Hazards and Bio ethics, Validation of utilities [Compressed air, steam, water systems, Heat Ventilation and Air conditioning (HVAC)] and Cleaning Validation, Standard operating procedures (SOPs), Concept of QC, QA, GMP, cGMP, GLP, GCP in labs & production processes, Documentation, Animal Care and Management of Laboratory Animals, Animal House CPCEA guidelines, Risk assessment and Management, Corrective Action and Preventive Action (CAPA), Handling of non-conformance, Relevant ISO and Quality Council of India (QCI) Standards

SECTION – B

Industrial Biochemistry and Scope: Introduction to Industrial Biochemistry and their Applications, Upstream and Downstream processing, Product development and their methods, Stages of the Product development Process, Analytical Method development and Validation - Parameters like accuracy, precision, linearity, Limit of Detection (LOD), Limit Of Quantification (LOQ), specificity, range and robustness.

Physicochemical properties in relation to biological action: effects of route of administration, drug targets, validation techniques of pharmaceutical targets, pharmacokinetics and pharmacodynamics of drugs, drug toxicity.

SECTION – C

Clinical and Medical Diagnostics and their Scope: Clinical diagnostic and Testing, *In-vitro* Diagnostic (IVD), Diagnostic Kits and their Development and applications, Basics of Clinical and Translational Research, Animal Cell Culture Technology & Scope, Artificial intelligence in healthcare

Pharmaceutical Regulatory Affairs: Pharmaceutical Regulatory Affairs and Scope, Regulatory Affairs in Product Management, Regulatory Affairs in Clinical Trials, Regulatory Affairs in R&D

SECTION - D

Intellectual Property Rights: Introduction to IPR, Types of IPR - Patents, Trademarks, Copyright and Related Rights, Industrial Design, Traditional Knowledge and Geographical Indications. Importance of IPR-patentable and nonpatentable, IPR and WTO regime - consumer protection and plant genetics resources.

Bioethics: Introduction to ethics and bioethics; Ethical and socioeconomic aspects of gene therapy, germline, somatic, embryonic and adult stem cell research. Ethical implications of GM crops, GMOs, human genome project, human cloning and bio-weapons

Suggested Readings:

- Regulatory guidelines of ICH, WHO and USFDA.
- R. Ian Freshney, Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Seventh Edition
- Good Laboratory Practice Regulations, by Sandy Weinberg, Fourth Edition Drugs and the Pharmaceutical Sciences, Vol.168
- Good Pharmaceutical Manufacturing practice, Rational and compliance by John Sharp, CRC Press
- Establishing a cGMP Laboratory Audit System, A practical Guide by David M. Bleisner, Wiley Publication. How to practice GLP by PP Sharma, Vandana Publications.
- Laboratory Auditing for Quality and Regulatory compliance by Donald C. Singer, Drugs and the Pharmaceutical Sciences, Vol.150.
- Pharmaceutical Regulatory Affairs - Selected Topics, CVS Subramanyam and J Thimmasetty, VallabhPrakashan Delhi – 2013
- Protection of Industrial Property rights by P. Das and Gokul Das

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO mapping matrix for BCH 201 (Industrial Biochemistry)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 201.1	2	1	3	3	3	3
201.2	3	-	3	3	3	3
201.3	2	1	3	3	3	3
201.4	2	1	3	3	3	3
Average	2.25	0.75	3	3	3	3

CO-PSO mapping matrix for BCH 201 (Industrial Biochemistry)

COs	PSO1	PSO2	PSO3	PSO4
BCH 201.1	3	3	3	3
201.2	3	3	3	3
201.3	3	3	3	3
201.4	3	3	3	3
Average	3	3	3	3

Elective
M.Sc. (Biochemistry) Semester - II
Paper: BCH – 202A
Clinical Biochemistry

Total Marks: 100

External Marks: 80

Internal Assessment: 20

Time allowed: 3 hrs

Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To bring awareness among students for practicing quality control for accuracy of results.
- To explain the patho-physiology and metabolic basis of common disorders.
- Assessment of organ function tests.

Course outcomes:

After successful completion of the course, students will be able to:

202A.1 Know the principles and practice of quality control, handling of biological fluids and their significance in maintaining good health; understand clinical significance of plasma proteins and blood disorders.

202A.2 Explain the role of enzymes and other biochemical markers in clinical diagnostics and organ function tests; use the knowledge of metabolism of xenobiotics in various interdisciplinary courses.

202A.3 Learn the etiology of disorders associated with carbohydrates, amino acids, lipids, nucleic acids, vitamins & minerals metabolism.

202A.4 Understand and explain disorders associated with various hormones, disorders of acid-base and electrolytes balance in the body and neuropsychiatric disorders.

SECTION-A

Clinical biochemistry and quality assurance: Biological samples (blood, urine and cerebrospinal fluid): chemical composition, collection, processing, storage and reservation; Quality control: accuracy, precision, Specificity, Sensitivity, Levy Jening's chart.

Blood: clinical significance and functions of plasma proteins (albumin, alpha 1-antitrypsin, hepatoglobin, ceruloplasmin, transferrin, C-reactive protein); Disorders of hemoglobin: thalassemia, anemia (different types) and porphyrias.

SECTION- B

Clinical enzymology: Enzymes as diagnostic tool; Clinically important enzymes: alkaline phosphatase, acid phosphatase, aldolase, creatine kinase, LDH, AST, ALT, lipase, amylase and 5'-nucleotidase; isoenzymes and their diagnostic importance. **Organ function tests:** Assessment of liver, kidney, exocrine pancreas and G.I. tract function tests. **Detoxification:** Phase I and Phase II reactions.

SECTION- C

Metabolic disorders: Disorders of carbohydrate metabolism: Diabetes mellitus, diabetic ketoacidosis, hypoglycemia, glycogen storage disease and galactosemia; glucose tolerance test; disorders of lipid: Refsum's disease, fatty liver and lipotropic factors, hypolipoproteinemia and hyperlipidemia. Atherosclerosis: pathogenesis and risk factors; Disorder of amino acid metabolism: Maple syrup urine disease, phenylketonuria, Alkaptonuria, cystinuria and homocystinuria; disorder of nucleic acid metabolism: Gout, Lesch-Nyhan Syndrome, Hypouricemia, Orotic Aciduria;

disorders of calcium, magnesium, phosphorous, iron, copper and selenium metabolism; disorders of fat soluble (A, D, E and K) and water soluble vitamins (Thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, biotin, folic acid, vitamin B₁₂ and ascorbic acid)

SECTION- D

Hormone disturbances: Disturbances related to protein hormones (anterior and posterior pituitary), steroid hormones and thyroid hormones.

Electrolyte and acid base balance: disorders of electrolytes (hyponatremia, hyponatremia, hypokalemia, hyperkalemia, hyperchloremia, hypochloremia); water and acid base balance (metabolic and respiratory acidosis, metabolic and respiratory alkalosis)

Neuropsychiatric disorders: Alzheimer's & Parkinson's disease.

Suggested readings:

1. Textbook of Biochemistry for Medical student by Vasudevan DM (2019), 9th edition, Jaypee Brothers Medical Publishers
2. Teitz text book of clinical chemistry (2016), 6th edition, Carl A. Burtis and Edward R. Ashwood, W. B. Saunders Company.
3. Harper's Biochemistry, 31st edition, by R.K. Murray, P.A. Hayes, D.K. Granner, P.A. Mayes and V.W.Rodwell (2018) Prentice Hall International.
4. Textbook of Biochemistry with Clinical Correlations, 6th edition by T.M. Devlin (2005).Wiley-liss.
5. Biochemistry by U. Satyanarayana (2019). Books and allied (P) Ltd.
6. Text Book of Biochemistry & Human Biology by G.P. Talwar (1989) Prentice Hall, New Delhi.

Teaching Learning Process

- Teaching is supported by Classroom Lectures, Powerpoint presentations and related videos.
- Oral or written assignments are assigned.
- Knowledge of the students is tested through surprise tests and internal assessments.

CO-PO Mapping Matrix for the course BCH-202A (Clinical Biochemistry)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH202A.1	3	3	3	2	3	3
BCH202A.2	3	3	-	2	2	3
BCH202A.3	3	3	-	2	2	2
BCH202A.4	3	3	-	2	-	2
Average	3	3	0.75	2	1.75	2.5

- **CO-PSO Mapping Matrix for the course BCH-202 (Clinical Biochemistry)**

COs	PSO1	PSO2	PSO3	PSO4
BCH202A.1	3	3	3	2
BCH202A.2	3	3	3	2
BCH202A.3	3	3	3	2
BCH202A.4	3	3	3	2
Average	3	3	3	2

Elective
M.Sc. (Biochemistry) Semester – II
Paper: BCH – 202B
Nutritional Biochemistry

Total Marks: 100

External Marks: 80

Internal Assessment: 20

Time allowed: 3 hrs

Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To focus on the health benefits of typical nutrients including macro and micro minerals and vitamins and of nutraceuticals and functional foods.
- To know the basic concepts of food toxicity and safety.
- To help students understand the nutritive value of common Indian foods and nutritional disorders.

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

202B.1 Acquire detailed knowledge regarding nutritional importance of different nutrients and how diet influences health.

202B.2 Explain the importance of vitamins and minerals for maintaining good health.

202B.3 Get an insight about the various food toxicants, food additives, nutraceuticals and functional foods

202B.4 Describe different nutritional disorders and various applications of major enzymes in food industry.

SECTION A

Composition of human body, Energy content of foods, respiratory quotient of food stuffs, measurement of energy expenditure (direct and indirect calorimetry), BMR: measurement and significance of BMR, factors affecting BMR; Specific dynamic action (SDA); Carbohydrates: nutritional importance, sources of available carbohydrates; fibres in nutrition: beneficial effects, adverse effects and their sources, glycemic index, alternative sweeteners; Lipids: nutritional importance, major classes of dietary lipids, properties and composition of plasma lipoproteins, essential fatty acids and their physiological functions; Proteins: nutritional importance, nitrogen balance, assessment of nutritive value of proteins, concept of balanced diet.

SECTION B

Minerals: nutritional significance, dietary sources, deficiency symptoms and toxicity symptoms of major and trace minerals Vitamins: dietary sources, physiological functions and specific deficiency diseases associated with fat and water soluble vitamins, hypervitaminosis of fat soluble vitamins

SECTION C

Food toxicity and safety: Microbial contamination, Environmental contamination, Natural food toxins and Antinutrients: naturally occurring food borne toxicants, protease inhibitors, hemagglutinin, hepatotoxins, allergens, oxalates, toxin from mushrooms, animal food stuffs and sea foods; Agricultural residues, Intentional food additives: types of food additives-attributes and related health concerns; Nutraceuticals: different types of Dietary supplements and typical ingredients of Functional foods

SECTION D

Applications of major enzymes in food industry

Nutritional disorders: Lipoproteins and cardiovascular disease: 'good' and 'bad' cholesterol, development of cardiovascular disease and risk factors for cardiovascular disease

Protein energy malnutrition: etiology, clinical features, metabolic disorders and management of Marasmus and Kwashiorkor diseases

Nutrition and Cancer: Associations between nutritional factors and common cancer sites; effect of different foods, beverages, physical parameters and other additional factors on cancer.

Suggested readings:

1. Biochemistry by U. Satyanarayana (2019). Books and allied (P) Ltd.
2. Essentials of Human Nutrition by J.Mannand A.S.Truswell (2015) 5th ed.Oxford University Press Inc., NewYork
3. Contemporary Nutrition by Wardlaw Smith (2016) 9th ed. McGraw Hill Inc., New York
4. Nutritional Biochemistry by S. Ramakrishnan and S.Venkat Rao (1995) T.R. Publications
5. *Food Chemistry* by Owen Fennema (2017) 5th ed. CRCPress.
6. Food Science Chemistry and Experimental Foods 2nd ed. by M. Swaminathan (1995). The Bangalore Printing and Publishing Co. Ltd.

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO Mapping Matrix for BCH–202B (Nutritional Biochemistry)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH-202B.1	3	1	-	-	1	1
BCH-202B.2	3	1	-	-	1	1
BCH-202B.3	3	1	3	-	1	1
BCH-202B.4	3	2	-	-	3	3
Average	3	1.25	0.75	-	1.5	1.5

CO-PSO Mapping Matrix for BCH–202B (Nutritional Biochemistry)

COs	PSO1	PSO2	PSO3	PSO4
BCH-202B.1	3	3	2	1
BCH-202B.2	3	3	2	1
BCH-202B.3	3	3	3	2
BCH-202B.4	3	3	3	3
Average	3	3	2.5	1.75

Core
M.Sc. (Biochemistry) Semester - II
Paper: BCH –203
Enzymology

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. The candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To introduce students to various theoretical and practical aspects of enzymology.
- To develop their interest in the structure, function and kinetics of enzyme and their role as catalyst and regulator of cell metabolism.
- It serves as foundation for more advanced enzymology courses.

Course outcomes: After successful completion, students will be able to:

- 203.1 Distinguish the fundamentals of enzyme properties, nomenclature, characteristics and mechanism.
- 203.2 Study of factors affecting enzymatic reactions, application of biochemical calculations for enzyme kinetics and plotting graphs based upon kinetic data.
- 203.3 Describe the concept of enzyme inhibition. Students will know how to construct enzyme inhibitors.
- 203.4 Conceptualize the co-operative behavior of enzyme, Allosteric enzyme and understanding of regulatory mechanism of enzyme action.

SECTION – A

Introduction: Historical perspectives; General characteristics; Nomenclature and classification; Introduction to the following terms with examples – Holoenzyme, apoenzyme, cofactors, coenzymes, prosthetic groups, metalloenzymes, turnover number, enzyme activity units (IU and Katal), and specific activity. Multienzyme systems and multifunctional enzymes with specific examples and significance. Enzyme specificity: **Types of specificity;** three-point attachment theory to explain stereospecificity; Lock-and-key hypothesis; Induced-fit hypothesis; Hypothesis involving strain or transition-state stabilization. **Enzyme Catalysis:** Role of $\text{NAD}^+/\text{NADP}^+$, FMN/FAD, coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, lipoic acid, biocytin, Vitamin B_{12} Coenzyme, and tetrahydrofolate coenzymes in enzyme catalysis; Common features of active sites; Reaction co-ordinate diagram; Proximity & orientation, acid-base catalysis, and covalent catalysis; Enzyme promiscuity; Mechanism of action of chymotrypsin, ribonuclease, carboxypeptidase, and lysozyme

SECTION – B

Enzyme assay: Introduction; Kinetic and coupled enzyme assays. **Enzyme Kinetics:** Factors affecting enzyme activity; Arrhenius plot; Derivation of Michaelis-Menten equation for unisubstrate reactions; K_m and its significance; K_{cat}/K_m and its importance; Measurement of K_m and V_{max} by Lineweaver-Burk plot and other linear transformations of MM equation; Bi-substrate reactions: Sequential and ping-pong mechanisms with examples and determination of K_m and V_{max} for each substrate (derivations excluded); Use of initial

velocity studies, product-inhibition studies and isotope exchange at equilibrium for determining the kinetic mechanism of a bisubstrate reaction.

SECTION - C

Methods of studying fast reactions: A brief account of rapid mixing techniques, flash photolysis and relaxation methods. **Enzyme inhibition:** Reversible (competitive, non- competitive, and uncompetitive) and irreversible (affinity labels and suicide inhibitors) enzyme inhibitors; Determination of K_i . **Investigation of active site structure:** Methods for identification of binding and catalytic sites- Trapping the enzyme-substrate complex, use of substrate analogues, chemical modification of amino acid side chains in enzymes, enzyme modification by proteases and effect of changing pH.

SECTION - D

Enzyme regulation: Coarse and fine control of enzyme activity; Enzyme induction & Repression; Feedback inhibition; Allosteric enzymes with aspartate transcarbamoylase as an example; Concerted and sequential models for action of allosteric enzymes; Negative and Positive Cooperativity; Hill plot; Scatchard plot; Regulation by reversible and irreversible covalent modification of enzymes; Isoenzymes. **Ribozyme and Abzyme, Pseudoenzymes**

Suggested readings:

1. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry by Trevor Palmer (2007). Horwood Publishing.
2. Fundamentals of Enzymology, 3rd edition, by Nicholas C. Price and Lewis Stevens (2009) Oxford University Press.
3. Principles of Enzymology for Food Science by J.R. Whitaker (2018). Marcel Dekkar Publishers.
4. Structure and Mechanism in Protein Science, 9th edition, by Alan Fersht (2017). W.H. Freeman and Co., NY.
5. Lehninger: Principles of Biochemistry, 8th edition, by David L. Nelson and M.M. Cox Maxmillan/ Worth publishers/ W.H. Freeman & Company.

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO mapping matrix for BCH 203 (Enzymology)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 203.1	2	2	-	1	-	-
203.2	3	3	-	1	-	1
203.3	2	2	2	1	2	2
203.4	3	2	--	-	-	-
Average	2.5	2.25	0.5	0.75	0.5	0.75

CO-PSO mapping matrix for BCH 203 (Enzymology)

COs	PSO1	PSO2	PSO3	PSO4
BCH 203.1	3	3	3	2
203.2	3	2	3	2
203.3	2	3	3	3
203.4	3	3	1	2
Average	2.75	2.75	2.5	2.5

Core
M. Sc. (Biochemistry) Semester - II
Paper: BCH-204
Molecular Biology-1

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions and covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. The candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To impart education in basic molecular mechanisms vital for cell survival.
- To educate students in molecular biology so that they can pursue advanced course and research.

Course outcome

- 204.1 Students learn about central diagram of molecular biology.
204.2 They also learn about DNA, RNA and protein synthesis.
204.3 They also learn about DNA damages and various repair mechanism.
204.4 Understand molecular mechanisms behind protein targeting.

SECTION - A

Basic Concepts of Genetic Information: Nucleic acids as the genetic material - experimental evidences; Chargaff's rules Structure of DNA, Structural polymorphism of DNA (A, B and Z-DNA) various forces responsible for stability of DNA, DNA topology, topological and geometric properties, DNA supercoiling, Topoisomerases in prokaryotes and eukaryotes, DNA organization in prokaryotes and eukaryotes, C-value paradox, denaturation: different ways for carrying out denaturation, renaturation: requirements, kinetics, significance, various classes of DNA: highly repetitive, moderately repetitive and unique sequence, RNA: structure and types.

SECTION - B

DNA replication, mutations and DNA repair: Possible modes of DNA replication, Meselson-Stahl experiment, DNA polymerases and other enzymes involved in DNA replication, Okazaki fragments, Mechanism of replication in prokaryotes and eukaryotes, inhibitors of DNA replication, molecular basis of mutations, DNA repair mechanisms like direct, base-excision, nucleotide-excision, mismatch, SOS and recombinational repair.

SECTION - C

Transcription and post-transcriptional modifications: RNA polymerase/s in prokaryotes and eukaryotes, DNA footprinting technique, initiation, elongation and termination of transcription in prokaryotes and eukaryotes, inhibitors of transcription, RNA replicase, reverse transcriptase, post-transcriptional modifications: different types of introns and their splicing mechanisms, processing of mRNA, rRNA and tRNA precursors, overlapping genes and split genes.

SECTION - D

Protein synthesis, targeting and degradation: Characteristics of the genetic code, biological significance of degeneracy, decoding the code, Wobble hypothesis, ribosomes structure and function in prokaryotes and eukaryotes, Aminoacyl tRNA-synthetases, various factors and steps involved in protein synthesis in

prokaryotes and eukaryotes, polyribosomes, post-translational processing, signal hypothesis and protein targeting to lysosomes, Plasma membrane, extracellular matrix and different compartment of mitochondria and chloroplast, protein degradation.

Suggested readings:

1. Molecular Biology of the Gene, Watson et al, 7th Edition.
2. Lehninger's Principles of Biochemistry, 8th edition.
3. Molecular Cell Biology, Lodish et al, 9th edition.
4. Principles of Biochemistry, Moran et. al., 5th edition.
5. Fundamentals of Biochemistry, Voet et. al, 6th edition.
6. Biochemistry, L Stryer. 9th edition.

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO mapping matrix for BCH 204 (Molecular Biology I)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 204.1	2	3	--	1	--	--
204.2	2	3	--	2	1	--
204.3	1	2	1	1	2	--
204.4	1	3	--	1	1	--
Average	1.5	2.75	0.25	1.25	1.0	--

CO-PSO mapping matrix for BCH 204 (Molecular Biology I)

COs	PSO1	PSO2	PSO3	PSO4
BCH 204.1	3	3	3	3
204.2	3	2	3	3
204.3	3	3	3	2
204.4	1	3	2	1
Average	2.5	2.75	2.75	2.25

Open Elective
M.Sc. (Biochemistry) Semester - II
Paper: BCH – 205
Food Biochemistry

Total Marks: 50
External Marks: 40
Internal Assessment: 10

Time allowed: 3 hrs
Credits: 2

Note: The examiner will set five questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & two others, selecting one from both sections.

Objectives:

- To focus on different sources of nutrients along with their nutritional importance.
- To help students know the basic concepts of food toxicity and safety and nutritional disorders.

Course outcomes:

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

- 205.1 Acquire detailed knowledge regarding dietary sources and nutritional importance of different nutrients.
- 205.2 Describe different food toxicants, nutritional disorders and various applications of major enzymes in food industry

SECTION A

Classes and sources of nutrients (overview), energy value of foods, Basal metabolic rate, specific dynamic action, nutritional importance of carbohydrates, Glycemic index, fibres in nutrition, nutritional importance of lipids, essential fatty acids, nutritional importance of proteins, nitrogen balance, mutual supplementation of proteins, concept of balanced diet, Vitamins: major functions, dietary sources, deficiency symptoms of fat soluble and water soluble vitamins, hypervitaminosis of fat soluble vitamins; Minerals: major functions, dietary sources, deficiency symptoms and toxicity symptoms of major and trace minerals

SECTION B

Food toxicity and safety: Microbial contamination, environmental contamination, natural toxins, agricultural residues, intentional food additives.

Applications of major enzymes in food industry

Nutritional disorders: Lipoproteins and cardiovascular disease: 'good' and 'bad' cholesterol, risk factors for cardiovascular disease.

Nutrition and Cancer: Associations between nutritional factors and common cancer sites; effect of different foods, beverages, physical parameters and other additional factors on cancer.

Suggested readings:

1. Biochemistry by U. Satyanarayana (2017). Books and allied (P) Ltd.
2. Essentials of Human Nutrition by J. Mann and A.S. Truswell (2015) 5th ed. Oxford University Press Inc., New York.
3. Contemporary Nutrition by Wardlaw Smith (2016) 9th ed. Mc Graw Hill Inc., New York.

4. Nutritional Biochemistry by S. Ramakrishnan and S. Venkat Rao (1995) T. R. Publications.
5. *Food Chemistry* by Owen Fennema (2017) 5th ed. CRC Press.
6. Food Science Chemistry and Experimental Foods by M. Swaminathan (1990). The Bangalore Printing and Publishing Co. Ltd.

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO Mapping Matrix for the course BCH-205 (Food Biochemistry)

Cos	PO1	PO2	PO3	PO4	PO5	PO6
BCH-205.1	3	3	-	-	3	-
BCH-205.2	3	3	1	-	3	-
Average	3	3	0.5	-	3	-

CO-PSO Mapping matrix for the course BCH-205 (Food Biochemistry)

Cos	PSO1	PSO2	PSO3	PSO4
BCH-205.1	3	3	3	1
BCH-205.2	3	3	3	1
Average	3	3	3	1

Core
M.Sc. (Biochemistry) Semester - II
Paper: BCH –206
Practical-3 (Based on papers BCH-201 and BCH-202A&B)

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 8hrs
Credits:4

Course outcomes:

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

206.1 Elucidate the basic elements of clinical biochemistry and specialized tests of biochemistry.

206.2 Develop the skills of performing basic biochemical tests important in clinical investigations and to develop familiarity with biochemical laboratory techniques.

206.3 Deal with the handling of the various biological specimens including the process of collection, preservation and storage.

206.4 Get an insight about the diseases of various organs such as pancreas, liver, bones, kidney, heart and muscle by estimating different enzymes and metabolites.

List of experiments*

1. Collection, preservation and physical examination of urine sample
2. Tests for analysis of abnormal urine constituents
3. To determine the blood group and Rh factor of the blood sample
4. Collection, preservation and separation of blood plasma and serum
5. To estimate urea in the given blood sample
6. To estimate creatinine and uric acid in the given serum sample
7. Estimation of glycated Hemoglobin in blood by enzymatic method.
8. Estimation of CRP in the given blood sample.
9. To determine albumin-globulin ratio in blood.
10. Quantitative estimation of SGPT and SGOT in the given serum sample
11. Quantitative estimation of LDH in the given serum sample
12. Determination of ESR by Westergren method
13. Determination of chloride and phosphorus in the given serum sample
14. Estimation of blood glucose in blood.
15. Determination of lipids level in blood.

*As per feasibility of practical(s), teacher concerned may conduct additional practical(s) in addition to the present list, which will also be the part of syllabus for evaluation.

CO-PO mapping matrix for BCH 206 (Practical-3)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH-206.1	3	3	1	1	3	3
BCH-206.2	3	3	1	1	3	3
BCH-206.3	3	3	1	1	3	3
BCH-206.4	3	3	1	1	3	3
Average	3	3	1	1	3	3

CO-PSO mapping matrix for BCH 206 (Practical-3)

COs	PSO1	PSO2	PSO3	PSO4
BCH-206.1	3	3	3	2
BCH-206.2	3	3	3	2
BCH-206.3	3	3	3	2
BCH-206.4	3	3	3	2
Average	3	3	3	2

Core
M.Sc. (Biochemistry) Semester - II
Paper: BCH –207
Practical-4 (Based on papers BCH-203 and BCH-204)

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 8hrs
Credits: 4

Course outcomes:

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

- 207.1 Learn about isolation and purity of nucleic acids
- 207.2 Develop the skills of extraction, purification assay of enzymes from plant and animal tissue.
- 207.3 Understand enzymes kinetics and enzymes immobilization
- 207.4 Understand partial purification of enzymes

List of Experiments*

1. Isolation of DNA from blood.
2. Isolation of RNA from blood.
3. Estimation of DNA by diphenylamine reaction
4. Estimation of RNA by orcinol reaction
5. Qualitative and quantitative estimation of DNA and RNA.
6. Assay of acid phosphatase enzyme from plant/animal tissue and calculation of specific activity
7. Assay of alkaline phosphatase enzyme from plant/animal tissue and calculation of specific activity
8. Effect of substrate concentration on enzyme activity of acid/alkaline phosphatase
9. Effect of enzyme concentration on enzyme activity of acid/alkaline phosphatase
10. Effect of temperature on the activity of acid/alkaline phosphatase
11. Effect of pH on the activity of acid/alkaline phosphatase
12. Determination of K_m and V_{max}
13. Determination of pH_{optima} of an enzyme
14. Demonstration of enzyme immobilization
15. Partial purification of an enzyme by Ammonium Sulphate fractionation

*As per feasibility of practical(s), teacher concerned may conduct additional practical(s) in addition to the present list, which will also be the part of syllabus for evaluation.

CO-PO mapping matrix for BCH 207 (Practical-4)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 207.1	3	2	2	3	-	3
207.2	3	2	2	3	-	3
207.3	3	2	2	3	-	3
207.4	3	2	2	3	-	3
Average	3	2	2	3	-	3

CO-PSO mapping matrix for BCH 207 (Practical-4)

COs	PSO1	PSO2	PSO3	PSO4
BCH 207.1	3	3	3	3
207.2	3	3	3	3
207.3	3	3	3	3
207.4	3	3	3	3
Average	3	3	3	3

Core
M. Sc. (Biochemistry) Semester - III
Paper: BCH – 301
Molecular Biology – II

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. The candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- The objective is to acquaint the students to most recent advances in molecular biology.
- Prepare students for finding careers and pursue Ph.D. in related fields.

Course outcomes:

- 301.1 Students learn about gene expression and its regulation at different levels
301.2 Students learn about jumping genes and interactions of molecules with nucleic acids
301.3 Explain how molecular defects can lead to development of cancer.
301.4 Students learn about development of Drosophila and concepts of genomics

SECTION - A

Gene regulation: Various levels of control of gene expression in prokaryotes and eukaryotes, operon concept, regulation of expression of lac, galactose, araBAD, tryptophan operons and lambda phages, regulation of ribosome synthesis, motifs involved in DNA- protein, protein-protein interactions; Various regulatory sequences in eukaryotes, molecular aspects of regulation of gene expression at transcription level viz. repression by nucleosomes, DNase sensitivity and hypersensitivity, histone modifications etc., at post-transcriptional level like regulation of RNA splicing, mi-RNA and Si-RNA mediated gene regulation, RNA transport, RNA stability; at translational, post-translational and protein degradation level,

SECTION - B

Transposable genetic elements: Non-replicative and replicative transposition, transposable genetic elements in bacteria, yeast, maize, drosophila and significance of transposable elements.

Interaction of nucleic acids with small molecules: Reactions of nucleic acids with non-carbon electrophiles, nitrogen electrophiles, carbon electrophiles, anticancer drugs, photochemical modifications of nucleic acids, effects of ionizing radiations on nucleic acids.

SECTION - C

Molecular Biology of Cancer: Benign and malignant tumors, types of cancers, cancer causing agents- radiations, chemical compounds, DNA and RNA viruses; mechanism of carcinogenesis; important characteristics of cancerous cells; proto-oncogenes and oncogenes, gain of function mutations of proto-oncogenes-growth factors, growth factor receptors, intracellular signal transducers, nuclear transcription factors, cell cycle control proteins, DNA repair proteins into oncogenes; Rb and P⁵³ as tumor suppressor genes, telomerase expression and immortalization of cells.

Cell death and cell renewal: Apoptosis (Programmed cell death), caspases: the executioners of apoptosis, central regulators of apoptosis: The Bcl-2 family.

SECTION – D

Drosophila development and its regulation: Various stages of oogenesis, blastulation, gastrulation to form three cell layers, morphogen gradient, details of three classes of pattern control genes like egg-polarity genes, segmentation genes, homeotic selector genes and imaginal discs.

Genomics: Structural genomics-construction of cytological maps based on banding pattern, physical maps based upon contigs, sequence-tagged sites (STSs), expressed-sequence tags (ESTs), genetic maps based upon RFLP, microsatellites, variable number tandem repeats; Map position- based cloning of genes; The human genome project; functional genomics- DNA microarray, serial analysis of gene expression (SAGE); comparative genomics- prokaryotic, chloroplast, mitochondria and eukaryotic genomes; evolution of genomes in the cereal grasses and mammals.

Suggested Readings:

1. Principles of Gene Manipulation, R.W. Old, S B Primose & R Twyman, 7th edition.
2. Principles of Genetics, Snustadet. al., 8th edition.
3. Molecular Cell Biology, Lodish et al, 9th edition.
4. Molecular Biology of the Gene, Watson et al, 7th Edition.
5. Nucleic acids in Chemistry and Biology, G M Blackburn & M.J. Gait, 3rd edition.

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO mapping matrix for BCH 301 (Molecular Biology II)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 301.1	2	3	-	1	1	-
301.2	2	2	1	1	-	1
301.3	1	3	-	-	1	1
301.4	2	1	-	1	-	1
Average	1.75	2.25	0.25	0.75	0.5	0.75

CO-PSO mapping matrix for BCH 301 (Molecular Biology II)

COs	PSO1	PSO2	PSO3	PSO4
BCH 301.1	3	3	3	3
301.2	3	3	3	2
301.3	3	2	2	2
301.4	2	2	2	2
Average	2.75	2.5	2.5	2.25

Core
M.Sc. (Biochemistry) Semester - III
Paper: BCH-302
Immunology

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. The candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives: The objective of this course is to:

- Learn about different components of immune system and how they work.
- To understand structure and function of immune system.
- Study mechanisms involved in immune system development and responsiveness.
- Failure of immune system will also be discussed

Course outcomes: After successful completion of course, students will be able to:

- 302.1 Compare and contrast the different types of immunity and their correlation for effective immune response, overview of immune system (including its cells and organs). Design and model of different types of immunoglobulins and antigens.
- 302.2 Conceptualization of molecular basis of Antigen Antibody interaction, immune cell interactions, recognition molecules and immunomodulatory molecules.
- 302.3 Understanding of genetic basis of diversity of immune response and also knowledge of immunization.
- 302.4 Knowledge of immune response against infectious agents and tumors, adverse effects of immune response including autoimmune disorders, hypersensitivity and immunodeficiency disorders.

SECTION - A

Introduction to immune system: Innate and acquired immunity, self vs non-self discrimination, structure and functions of primary and secondary lymphoid organs.

Cells involved in immune responses: Phagocytic cells and their killing mechanisms; T and B lymphocytes. **Nature of antigen and antibody:** Antigens vs immunogen, haptens, structure and functions of immunoglobulins; isotypic, allotypic and idiotypic variations.

SECTION - B

Major Histocompatibility Complex (MHC) genes and products: polymorphism of MHC genes, role of MHC antigens in immune responses, MHC antigens in transplantation.

Humoral and cell mediated immune responses: Kinetics of primary and secondary immune responses, complement activation and its biological consequences, antigen processing and presentation, cytokines and co-stimulatory molecules- role in immune responses, Immune cell interactions.

SECTION - C

Generation of diversity in immune system: Clonal selection theory- concept of antigen specific receptor, organization and expression of immunoglobulin genes- generation of antibody diversity, Organization and expression of T-cell receptor genes- generation of T cell receptor diversity. **Immunization:** Active & passive immunization.

SECTION - D

Tolerance vs activation of immune system: Immune tolerance, immunosuppression, hypersensitivity (Types I, II, III and IV). **Immune responses in diseases:** Immune responses to infectious diseases- viral, bacterial and protozoal; cancer and immune system, immunodeficiency disorders and autoimmunity.

Suggested Readings:

1. Immunology, 13th ed. by Roitt et al., Mosby Publications.
2. Cellular and Molecular Immunology, 10th ed. by Abbas and Litchman, Saunders Publication.
3. Kuby Immunology, 7th ed. by R.A. Goldsby et al, W.H. Freeman & Co.
4. Immunology: an introduction, 4th Edition by Ian R Tizard, Saunders College Publishing.

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessment

CO-PO mapping matrix for BCH 302 (Immunology)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 302.1	2	2	--	1	1	--
302.2	2	3	--	1	2	--
302.3	1	3	--	1	--	--
302.4	1	3	--	2	--	2
Average	1.5	2.75	--	1.25	0.75	0.5

CO-PSO mapping matrix for BCH 302 (Immunology)

COs	PSO1	PSO2	PSO3	PSO4
BCH 302.1	3	3	3	3
302.2	3	3	2	3
302.3	2	3	2	2
302.4	3	2	2	2
Average	2.75	2.75	2.25	2.5

Core
M.Sc. (Biochemistry) Semester - III
Paper: BCH – 303
Plant Biochemistry

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objective:

- To provide students a comprehensive understanding of different plant metabolic processes such as carbon metabolism, nitrogen metabolism, plant hormones and biochemical defense mechanisms against pathogen.
- To learn about secondary plant metabolites and plant development biology

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

303.1 Understand the light phase of photosynthesis and pathways of CO₂ assimilation in C₃, C₄ and CAM plants.

303.2 Get an insight about the Sucrose and starch metabolism in plants and Electron transport chain in plant mitochondria.

303.3 Explain the various plant processes viz. nitrate assimilation, biological nitrogen fixation in plants. Understand the function of plant hormones.

303.4 Understand the secondary metabolites of plants and plant development biology

SECTION – A

Chemical and physical composition of higher plant cell wall. **Light reactions of Photosynthesis:** Photosynthetic pigments, chlorophyll excitation by absorption of light energy and its return to the ground state, Requirement of an antenna to capture light, van Niel equation, Hill equation, Cyclic electron transport in purple photosynthetic bacterium, Red drop and Emerson enhancement effect, Photosystem I & II, Non-cyclic, cyclic and pseudocyclic photosynthetic electron transport, Inhibitors of non-cyclic electron transport, Regulation of energy distribution between PS I and PS II, Photophosphorylation: coupling between electron transport and phosphorylation, chemiosmotic hypothesis, chloroplast ATP synthase, binding change mechanism of ATP synthesis and uncouplers of photophosphorylation.

SECTION – B

Pathway and regulation of CO₂ assimilation in C₃, C₄ & CAM plants. Photorespiration: pathway and significance. Metabolism of Sucrose and Starch: Biosynthesis and degradation of starch and sucrose; role of fructose 2, 6- biphosphate in carbon partitioning between sucrose and starch. **Electron transport in plant mitochondria:** Electron transport complexes and pathway of electron flow in plant mitochondria; cyanide - resistant respiratory pathway.

SECTION – C

Nitrogen Metabolism: Nitrogen Cycle; Nitrate Assimilation: nitrate uptake, nitrate & nitrite reduction and regulation of nitrate assimilation. **Biological nitrogen fixation:** Nitrogen fixing organisms, structure and mechanism of action of nitrogenase, Legume-Rhizobium symbiosis (A brief account), Leghaemoglobin, Strategies for protection of nitrogenase against the inhibitory effect of oxygen, Ammonia assimilation, *nif* genes of *Klebsiella pneumoniae* and their regulation, and synthesis of amides and ureides. Biochemical defense mechanisms in plants against pathogens;

Plant hormones: Physiological effects and molecular mechanism of action of auxins, gibberellins, cytokinins, ABA and ethylene. Phytochromes as light sensors.

SECTION – D

Secondary plant metabolism: Primary and secondary metabolites; Isoprenoids: introduction, different classes with examples; Alkaloids: definition, classification according to their heterocycles with examples; physiologically active alkaloids (used in medicine and plant chemical defense); Phenylpropanoids: Introduction; overview of products of the phenylpropanoid metabolism; Flavonoids: nature; classification of aglycons with examples; functions of flavonoids; Nature of Tannins, Cyanogenic glycosides and Glucosinolates.

Plant Development: Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum*.

Suggested Reading:

1. Biochemistry and Molecular Biology of Plants by Bob, B. Buchanan, W. Gruissem and R.L. Jones 2nd ed. (2015). Published by American Society of Plant Physiologists and distributed by Panima Educational Book Agency, New Delhi.
2. Plant Biochemistry & Molecular Biology, 4th ed., by Hans-Walter Heldt (2010), Academic Press
3. Introduction to Plant Biochemistry, T.W. Goodwin and E.I. Mercer (1983). Pergamon Press, Oxford
4. Plant Physiology, 6th edition, by L.Taiz and E Zeigler (2010), Sinauer Associates, Inc., Publishers

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO Mapping Matrix for the course BCH – 303 (Plant Biochemistry)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH-303.1	3	3	-	1	1	1
BCH-303.2	3	3	-	1	1	1
BCH-303.3	3	3	-	1	1	1
BCH-303.4	3	3	-	2	2	3
Average	3	3	-	1.25	1.25	1.5

CO-PSO Mapping Matrix for the course BCH – 303 (Plant Biochemistry)

COs	PSO1	PSO2	PSO3	PSO4
BCH-303.1	3	3	3	1
BCH-303.2	3	3	3	1
BCH-303.3	3	3	3	1
BCH-303.4	3	3	3	3
Average	3	3	3	1.5

Core
M.Sc. (Biochemistry) Semester - III
Paper: BCH – 304
General Microbiology

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To provide the students a basic knowledge of microorganisms and their metabolic pathways.
- To focus on the importance of microbiology at industrial level and in general human welfare.

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

- 304.1 Describe the physical & chemical agents for the control of microorganisms for biosafety purpose.
304.2 Explain Microbial Tissue Culture and the importance of microorganisms in food and industrial microbiology.
304.3 Explain bacterial genetics and virus structure. Learn about biochemical activities of microorganisms
304.4 Get an insight about the pathogenicity of microorganisms and antimicrobial chemotherapy among students.

SECTION – A

Members of the microbial world; Impact of microorganisms on humans; Gram +ve and Gram –ve bacteria; Control of microorganisms by physical & chemical agents; Nutritional types of microorganisms; Culture media; Pure culture techniques; Microbial Growth curve, Continuous culture of microorganisms; influence of environmental factors on growth: solutes and water activity, pH, temperature, oxygen concentration, pressure and radiations; Biofilms

SECTION – B

Industrial Microbiology: Biosafety, Maintenance and Preservation of pure cultures, Microbial Tissue Culture (MTC), Industrial Microbes and their uses in production of food, antibiotics and hormones, Production of humulin by Recombinant DNA Technology, Biofertilizers, Genetically modified Microorganisms

Fermentations: Lactic and mixed acid fermentations; Amino acid fermentation by *Clostridium* species and the Stickland reaction; fermentations without substrate level phosphorylation; Fermentors; Characteristics of large scale fermentations; Major products of industrial microbiology: Antibiotics (penicillin and tetracyclin), Alcohol and alcoholic beverages, Organic compounds (citric acid); Yeast as a food and food supplement; Microbes as products: Biosensors and Bioinsecticides

SECTION – C

Bacterial Genetics: Transformation, Transduction & Conjugation

Biochemical activities of Microorganisms: Extracellular enzymatic activities of microorganisms, Carbohydrate fermentation, Triple sugar-iron agar test, IMViC test, Hydrogen sulphide test, Urease test, Litmus milk reactions, Nitrate reduction test, Catalase test, Oxidase test, Utilization of amino acids, Acetogenesis; Methanogenesis; Microbial Biodegradation of Petroleum and Xenobiotics;

Biodegradable plastics; **Virus:** Structure and general characteristics; cultivation of viruses; Viroids and Prions

SECTION – D

Microbial diseases and their control: Pathogenicity of microorganisms: Host-parasite interactions; pathogenesis of viral diseases; Bacterial pathogenesis; pathogenicity islands; Toxigenicity: General characteristics of Exotoxins and Endotoxins,

Antimicrobial chemotherapy: General Characteristics of antimicrobial drugs, Mechanism of action of antibacterial drugs: inhibitors of cell wall synthesis, protein synthesis inhibitors, metabolic antagonists, nucleic acid synthesis inhibitors; factors influencing antimicrobial drug effectiveness, Mechanisms of drug resistance; Mechanism of action of Antifungal drugs and Antiviral drugs

Suggested Readings:

1. Microbiology by L.M. Prescott, J.P. Harley and D.A. Klein 7th ed. W.M.C. Brown Publishers.
2. Brock Biology of Microorganisms 15th ed. by M.T. Madigan, J.M. Martinko, J. Parker (2015) Prentice Hall International, Inc.
3. The Microbial World, 5th ed. By R.Y. Stainer, J.L. Ingraham, M.L. Wheelis and P.R. Painter, Prentice-Hall of India, New Delhi.
4. Microbiology, 5th ed. By M.J. Pelczar, E.C.S. Chan et al. McGraw-Hill Book Company.
5. Microbiology: Fundamental and Applications, 2nd ed. by R.M. Atlas, Maxwell Macmillan, International Edition.

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO matrix for the course BCH – 304 (General Microbiology)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH-304.1	3	3	3	2	1	2
BCH-304.2	3	3	3	3	3	3
BCH-304.3	3	3	-	1	3	3
BCH-304.4	3	3	3	2	2	3
Average	3	3	2.25	2	2.25	2.75

CO-PSO matrix for the course BCH – 304 (General Microbiology)

COs	PSO1	PSO2	PSO3	PSO4
BCH-304.1	3	3	3	1
BCH-304.2	3	3	3	1
BCH-304.3	3	3	3	3
BCH-304.4	3	3	3	3
Average	3	3	3	2

Core
M. Sc. (Biochemistry) Semester - III
Paper: BCH-305
Seminar

Total Marks: 50

Credits: 1

Course outcomes

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

305.1 Work independently, critically analyze research literature and use different digital sources to explain the concepts of Biochemistry.

305.2 Demonstrate latest scientific developments from disciplinary perspective to its professional and everyday use.

305.3 Formulate logical and convincing arguments and to substantiate critical readings of scientific texts in order to develop scientific temper in biological sciences.

CO-PO mapping matrix for BCH 305 (Seminar)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 305.1	3	3	2	3	2	-
305.2	3	3	3	2	3	-
305.3	3	3	3	3	-	-
Average	3	3	2.66	2.66	1.66	-

CO-PSO mapping matrix for BCH 305 (Seminar)

COs	PSO1	PSO2	PSO3	PSO4
BCH 305.1	3	3	2	2
305.2	3	3	2	2
305.3	3	3	2	3
Average	3	3	2	2.33

Open Elective
M.Sc. (Biochemistry) Semester - III
Paper: BCH – 306
Clinical Diagnostics in Health and Disease

Total Marks: 50

External Marks: 40

Internal Assessment: 10

Time allowed: 3 hrs

Credits: 2

Note: The examiner will set five questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & two others, selecting one from both sections.

Objective:

- To provide students with the basic knowledge and understanding of the role of clinical biochemistry in diagnosis of various diseases.

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

306.1 Have an overview of clinical biochemistry in the diagnosis of common diseases.

306.2 Have an overview of common biochemical and molecular markers of common diseases.

SECTION - A

Introduction to health and disease; **General biochemical test:** Blood group, Hb, total cell count, differential cell count (TLC and DLC), ESR, Bleeding time, clotting time, Urine analysis (protein, sugar and pigments), blood sugar, GTT and acetylated Hb. **General microbiological tests:** culture and sensitivity (urine and blood) tests. **Biochemical tests in clinical medicine– diagnostic tests and their clinical significance:** Liver function tests: SGOT, SGPT, ALP; Kidney function tests: Urea and creatinine; Cardiac function tests: blood pressure, lipid profile – HDL-c, LDL-c, total cholesterol, triglycerides, electrolytes; lung function tests.

SECTION - B

Molecular diagnosis of viral diseases: HIV (I and II), H1N1, Chickungunya, Dengue, viral hepatitis (B and C). **Diagnosis of infectious diseases:** tuberculosis, cholera, Typhoid and malaria; TORCH – panel; Infection in pregnancy; microscopic examination of body fluids, ELISA and PCR tests.

Suggested readings:

1. Teitz text book of clinical chemistry and Molecular diagnostics (2016), 6th edition, Carl A Burtis and Edward R Ashwood, W B Saunders Company.
2. Harper's Biochemistry, 32th ed., by R.K.Murray, P.A.Hayes, D.K. Granner, P.A. Mayes and V W Rodwell (2019), Prentice Hall International.
3. Textbook of Biochemistry with Clinical Correlations, 5th ed., T.M. Devlin (2002), Wiley-Liss.
4. Biochemistry, 6th ed., U. Satyanarayana (2019), Books and allied (P) Ltd.

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.

- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO mapping matrix for BCH 306 (Clinical Diagnostics in Health and Disease)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 306.1	3	3	-	2	1	2
306.2	3	3	-	2	1	2
Average	3	3	-	2	1	2

CO-PSO mapping matrix for BCH 306 (Clinical Diagnostics in Health and Disease)

COs	PSO1	PSO2	PSO3	PSO4
BCH 306.1	2	3	2	2
306.2	2	3	2	2
Average	2	3	2	2

Open Elective
M.Sc. (Biochemistry) Semester - III
Paper: BCH – 306A
Summer/Industrial Training
(Only for Biochemistry students)

Total Marks: 50

The students M.Sc. Biochemistry entering in 3rd semester of their programs(PG) w.e.f 2023-24 onwards will be allowed to opt for summer/Industrial training in lieu of open elective paper (BCH-306) keeping in view the following guidelines:-

1. Can be opted in 3rd semester only
2. Can do the summer/industrial training only after taking permission from the Chairperson of the department in writing.
3. Will be of minimum 6 weeks duration and can be done only during summer vacation falling in the period intervening between 2nd and 3rd Semester.
4. Can be done with a recognized industry research laboratory/company.
5. Every student opting for summer training will submit a report separately and present the same before a committee of the three teachers constituted by the chairperson of the department. The committee will award the marks out of 50 after evaluating the report and performance of the student during presentation.
6. Student will append a certificate in the report from the industry/research laboratory/company where she has done summer training.
7. No TA/DA or stipend will be provided by the University for doing the summer training.

Course outcomes:

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

1. Impart practical and project based training for preparing students to pursue higher education and career in research in the field of life sciences.
2. Develop problem solving innovative thinking with strong communication and writing skills, develop understanding of biological sciences with respect to recent knowledge and techniques.
3. Articulate specific ideas, scientific writing authentic reporting and effective presentation skills.

CO-PO mapping matrix for BCH 306A (Summer/Industrial Training Project Report)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 306A.1	3	3	3	3	2	3
306A.2	3	3	3	3	2	3
306A.3	3	3	3	3	2	3
Average	3	3	3	3	2	3

CO-PSO mapping matrix for BCH 306A (Summer/Industrial Training Project Report)

COs	PSO1	PSO2	PSO3	PSO4
BCH 306A.1	3	3	3	3
306A.2	3	3	3	3
306A.3	3	3	3	3
Average	3	3	3	3

Core
M.Sc. (Biochemistry) Semester - III
Paper: BCH –307
Practical-5 (Based on papers BCH-301 and BCH-302)

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 8hrs
Credits: 4

Course outcomes:

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

- 307.1 Develop skills in carrying out research projects by employing molecular biology and basic immunological techniques
- 307.2 Learn about cDNA preparation and Transcript expression by RT-PCR
- 307.3 Acquire insight knowledge regarding the important methods in Molecular Biology and immunology and able to exhibit their proficiency and skills in research.
- 307.4 Understand the polymorphism in DNA

List of experiments*

1. Preparation of Master Mix for PCR analysis
2. To perform amplification of genes by PCR
3. To perform RFLP using restriction enzymes
4. Determination of molecular weight of DNA fragments on agarose gel electrophoresis
5. To study the polymorphism in DNA using Single-Strand Confirmation Polymorphism condition
6. To demonstrate cDNA synthesis and Transcript expression by RT-PCR
7. Electrophoresis of RNA on denaturing gels
8. To perform the Bisulfite conversion of DNA
9. To know the methylation pattern at DNA (By Bisulfite conversion)
10. Electrophoretic separation of isoenzymes
11. ELISA
12. Immunoprecipitation
13. Immunoblotting
14. Immunodiffusion
15. Purification of IgG from serum

*As per feasibility of practical(s), teacher concerned may conduct additional practical(s) in addition to the present list, which will also be the part of syllabus for evaluation.

CO-PO mapping matrix for BCH 307 (Practical-5)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 307.1	3	3	2	3	-	3
307.2	3	3	2	3	-	3
307.3	3	3	2	3	-	3
307.4	3	3	2	3	-	3
Average	3	3	2	3	-	3

CO-PSO mapping matrix for BCH 307 (Practical-5)

COs	PSO1	PSO2	PSO3	PSO4
BCH 307.1	3	3	3	3
307.2	3	3	3	3
307.3	3	3	3	3
307.4	3	3	3	3
Average	3	3	3	3

Core
M.Sc. (Biochemistry) Semester - III
Paper: BCH –308
Practical-6 (Based on papers BCH-303 and BCH-304)

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 8hrs
Credits: 4

Course outcomes:

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

- 308.1 Understand and develop the skills in the preparation of microbial media and to get more familiar about the aseptic techniques to perform routine culture handling tasks safely and effectively.
- 308.2 Exhibit proficiency in the isolation of cultures by various methods (Serial dilution, Spread plate and Streak plate methods)
- 308.3 Demonstrate skill in taking up basic research projects and findings by employing microbiological concepts and principles.
- 308.4 Develop skills and knowledge to conduct basic research work in the field of Plant Biochemistry.

List of experiments*

1. To study Microbiology laboratory safety rules and guidelines
 2. To study some of the routinely used equipments in microbiology laboratory
 3. Storage of microorganisms and Maintenance of pure culture.
 4. Preparation of solid and liquid media for growth of microorganisms
 5. Isolation of bacteria from soil and maintenance of microorganisms by plating, streaking and serial dilution method
 6. To perform slant and stab culture
 7. To perform Gram staining in order to differentiate between gram positive and gram negative bacteria
 8. Demonstration of Total Plate Count
 9. Antimicrobial susceptibility testing and MICs determination.
 10. Calculation of IC₅₀ value.
 11. To demonstrate detection and confirmation of *S. aureus* and *Salmonella*.
 12. Widal test and Interpretation
 13. To demonstrate detection and confirmation of *Coliforms* and *E. coli* in water.
 14. Estimation of chlorophyll content in the leaves
 15. Estimation of ascorbic acid in lemon juice
 16. To determine the activity of polyphenol oxidases
 17. To estimate titrable acidity in fruits
- *As per feasibility of practical(s), teacher concerned may conduct additional practical(s) in addition to the present list, which will also be the part of syllabus for evaluation.

CO-PO mapping matrix for the course BCH-308

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH-308.1	3	3	3	3	3	3
BCH-308.2	3	3	3	3	3	3
BCH-308.3	3	3	3	3	3	3
BCH-308.4	3	3	-	-	2	1
Average	3	3	2.25	2.25	2.75	2.5

CO-PSO mapping matrix for the course BCH-308

COs	PSO1	PSO2	PSO3	PSO4
BCH-308.1	3	3	3	2
BCH-308.2	3	3	3	2
BCH-308.3	3	3	3	2
BCH-308.4	3	3	3	2
Average	3	3	3	2

Core
M.Sc. (Biochemistry) Semester – IV
Paper: BCH – 401
Biotechniques

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objective:

- To introduce the student about the radioisotopic, fractionation, molecular biology, immunological and spectroscopic techniques, their principles and applications.

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

- 401.1 Know the radio-isotopic techniques and their application in biological science research.
401.2 Understand the basic techniques of molecular biology and relate modern DNA technology for disease diagnosis and therapy.
401.3 Know the antigen antibody interactions, experimental methods of monoclonal antibody synthesis and types of vaccines.
401.4 Gain insight knowledge of the interaction of matter with electromagnetic radiations that will help to understand the chemical structure of molecules

SECTION - A

Radioisotope techniques: Basic concepts (types of radioactive decay, rate of radioactive decay, radioactive isotopes and their half-lives and units of radioactivity); GM and scintillation counter; autoradiography; specific activity of a radioisotope; safety aspects; applications of radioisotopes in biological sciences.

Centrifugation: Basic principles; different types of centrifuges; types of rotor; analytical and preparative ultracentrifugation methods.

SECTION - B

Molecular biology techniques: Isolation of DNA and RNA, purification and quantification of nucleic acids; Electrophoresis of nucleic acids: agarose gel electrophoresis, pulse field electrophoresis; capillary electrophoresis; microchip electrophoresis; DNA sequence analysis methods: Sanger dideoxy method, Maxam Gilbert chemical method and Fluorescence method; Polymerase chain reaction: principles, process, design and optimization; different types of PCR: allele specific, nested, multiplex and real-time PCR; ligase chain reaction; SNP and application in molecular diagnostics; DNA fingerprinting: applications and prospects; restriction fragment length polymorphism (RFLP) and its uses.

SECTION - C

Immunotechniques: Immunoprecipitation; agglutination; RIA; ELISA; ELISPOT; immunoblotting; immunofluorescence assays; cytotoxic assay; hybridoma technology for production of monoclonal antibody - principles, techniques and applications; designing chimeric and humanized antibodies; vaccines: types and their role in prevention of diseases; Flow cytometry and data analysis, FACS analysis.

SECTION - D

Spectroscopy: Nature of electromagnetic radiations; principles of biophysical methods used for analysis of biopolymer structure - UV, Visible, Infrared, Raman, Fluorescence and NMR spectroscopy; ORD and CD; Atomic absorption spectroscopy (AAS).

Suggested readings:

1. Kuby Immunology, 10th Edition
2. Physical Biochemistry, 3rd edition, by K. E Van Holde.
3. Principles and Techniques of Practical Biochemistry, 8th edition by Keith Wilson and John Walker.
4. Physical Biochemistry, 2nd edition, by D Friefelder.
5. Biophysical Chemistry: Principles and Techniques, 6th edition by A Upadhyay, K Upadhyay and N Nath.

CO-PO mapping matrix for BCH 401 (Biotechniques)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 401.1	3	-	2	2	-	2
401.2	3	1	2	-	-	1
401.3	3	-	2	1	2	2
401.4	2	1	1	1	-	1
Average	2.75	0.5	1.75	1.0	0.5	1.5

CO-PSO mapping matrix for BCH 401 (Biotechniques)

COs	PSO1	PSO2	PSO3	PSO4
BCH 401.1	3	3	2	1
401.2	3	2	3	2
401.3	2	3	3	2
401.4	3	2	2	2
Average	2.75	2.5	2.5	1.75

Core
M.Sc. (Biochemistry) Semester - IV
Paper: BCH – 402
Genetic Engineering

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objective:

- To provide students a basic knowledge of genetic engineering for gene transfer into bacteria, yeast, plants, and animals as well as recombinant protein production in bacteria and eukaryotic cells.

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

- 402.1 Understand the basic of genetic engineering and steps involved in a gene cloning experiment.
402.2 Know the various methods of gene transfer into *E. coli*, yeast, plant cells and animal cell and also know how to construct a genomic/cDNA library
402.3 Gain knowledge of recombinant protein production in bacteria and eukaryotic cells.
402.4 Understand Morphogenesis and organogenesis in animals

SECTION- A

Gene cloning strategies: Isolation and purification of nucleic acid and its quantification and analysis; Molecular tools and their applications; Restriction endonucleases; DNA modification enzymes; Site directed mutagenesis; Cloning vectors; Ligation of DNA fragments: Linkers, adapters and homopolymeric tailing; Construction of genomic library: mRNA enrichment; Reverse transcription; Synthesis of cDNA and library construction, Oligonucleotide synthesis, purification, and its application in screening of libraries.

SECTION- B

Expression vectors: Choice of expression system; Expression in bacterial, yeast, insect and mammalian cells; Baculovirus expression systems; Expression of heterologous genes; Factors affecting the expression of cloned genes; Codon bias; Vector engineering and codon optimization; Ti-plasmid

Transgenic and gene knockout technologies: Transgenic methodology; Transgenic animals and plants; Targeted gene replacement; chromosome engineering.

Stem cells: Stem cells and their properties, medical applications of adult stem cells, embryonic stem cells and therapeutic cloning.

SECTION- C

Studying gene expression and function: Studying the transcript of a cloned gene; Identifying protein binding sites on a DNA molecule; Identifying control sequences by deletion analysis; Identifying and studying the translation product of a cloned gene by HRT & HART. Studying protein-protein

interactions(Phage display and the yeast two hybrid systems). Production of Proteins from cloned genes: Expression in *E. coli* (Vectors for expression of foreign genes in *E. coli*, promoters used in expression vectors, general problems with the production of recombinant protein in *E. coli*); Production of recombinant protein by eukaryotic cells (Recombinant protein production in yeast, insect cells and mammalian cells; Pharming- recombinant protein production from live animals and plants); Recombinant protein purification using His-tag. Importance of gene cloning in medicine for the production of recombinant pharmaceuticals

SECTION- D

Morphogenesis and organogenesis in animals : Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.

Suggested Readings:

1. Gene Cloning and DNA Analysis - An Introduction, 8th edition, by T. A. Brown (2018), Blackwell Publishing.
2. Molecular Biotechnology - Principles & applications of Recombinant DNA, 6th ed., Bernard R. Glick, Cheryl L. Patten (2018), ASM Press.
3. Principles of Gene Manipulation, 7th ed., Sandy B. Primrose, Richard Twyman (2006), Blackwell Scientific Publication.
4. Analysis of Genes and Genomes, 9th ed. (2015) by Richard J Reece, John Wiley & Sons, Ltd.
5. Beier F.K, Crespi R.S and Straus T. Biotechnology and Patent protection, Oxford and IBH Publishing Co. New Delhi.
6. Rajmohan Joshi (Ed.) 2006. Biosafety and Bioethics, Isha Books, Delhi
7. Developmental Biology (9th Edition) By Scott F. Gilbert

Teaching Learning Process

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.
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CO-PO mapping matrix for BCH 402 (Genetic Engineering)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 402.1	3	2	1	2	-	2
402.2	3	2	1	2	-	2
402.3	3	2	1	2	-	2
402.4	3	1	3	2	-	2
Average	3	2	1.5	2	-	2

CO-PSO mapping matrix for BCH 402 (Genetic Engineering)

COs	PSO1	PSO2	PSO3	PSO4
BCH 402.1	3	3	3	3
402.2	3	3	3	3
402.3	3	3	3	3
402.4	2	2	3	3
Average	2.75	2.75	3	3

Core
M.Sc. (Biochemistry) Semester - IV
Paper: BCH – 403
Biostatistics and Bioinformatics

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objective:

- To familiarize the student with the science of biological data analysis using statistical and computational tools.

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

403.1 Understand the basic statistics and know how to analyse the biological data.

403.2 Equip the students to infer their results in a better way which is essential to get scientific data published in reputed journals.

403.3 Understand the fundamentals of bioinformatics.

403.4 Know how to use biological databases, retrieve information and link the wet and dry lab knowledge for better understanding of biological phenomenon's. To learn about Genome data-high throughput sequencing (NGS Platform).

SECTION - A

Fundamentals of Statistics: Arithmetic mean, median, mode; measures of variation: standard deviation, variance, coefficient of variation; properties; correlation: types and methods; simple, multiple, linear and non linear correlation, Spearman's correlation, rank correlation; regression: linear and curvilinear regression (for X and Y only), regression lines by least square method, regression equations of X on Y and Y on X only; sample size; power of study, sampling techniques, handling and description of data

SECTION - B

Tests of Significance: Null hypothesis; standard error; level of significance; degrees of freedom; significance of mean for large samples; significance in means for small samples (students t-test); significance in ratio of two samples; F test (for difference between variance of two samples); chi square test; analysis of variance (ANOVA) test for one and two way classification; applications of various online tools: SPSS, Minitab, XLSTAT etc.

SECTION - C

Fundamentals of Bioinformatics: Introduction to bioinformatics; concept of databases; biological databases; integration of databases; applications and problems in information retrieval from biological databases; Pairwise sequence comparisons by DOT-MATRIX and dynamic programming; Global (Needleman and Wunsch algorithm) and local (Smith and Waterman algorithm) alignments; Measures of sequence similarity (Alignment score, % sequence identity; percentage similarity; statistical scores—E, P

and Z); Heuristic approaches for database searching; SP scoring; multidimensional dynamic programming; progressive sequence alignment approach.

SECTION - D

Applications of Bioinformatics: Phylogenetic analysis (phylogeny, Phylogenetic tree, construction methods of Phylogenetic tree and Phylogenetic programs); protease digestion mapping; protein structure analysis; protein secondary structure prediction; Homology modelling (principles and procedures);

Genome data-high throughput sequencing (NGS Platform): Assembly and mapping of reads, and annotation with functional features – Practical use of scripts for NGS data analysis; Molecular Docking; Protein-ligand and Protein-protein interactions, Online tools, Data generation and analysis.

Suggested Readings:

1. Statistical Methods by S P Gupta 46th ed. (2017), Sultan Chand and Sons. New Delhi
2. Fundamentals of Mathematical Statistics, S C Gupta and V K Kapoor (2014), Sultan Chand and Sons.
3. Essential Bioinformatics, JinXiong (2007), Cambridge University Press.
4. Bioinformatics for Dummies, Jean-Michel Claverie, Cedric Notredame (2003), John Wiley and Sons.
5. Introduction to Bioinformatics, 5th ed., Arthur M. Lesk (2019) Oxford University Press.
6. Fundamental Concepts of Bioinformatics (2003), Dan E. Krane, Michael L Raymer.

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO mapping matrix for BCH 403 (Biostatistics and Bioinformatics)

Cos	PO1	PO2	PO3	PO4	PO5	PO6
BCH 403.1	3	2	-	1	-	2
403.2	3	2	-	2	-	3
403.3	3	2	-	2	-	2
403.4	3	2	-	2	-	3
Average	3	2	-	1.75	-	2.5

CO-PSO mapping matrix for BCH 403 (Biostatistics and Bioinformatics)

Cos	PSO1	PSO2	PSO3	PSO4
BCH 403.1	3	3	3	3
403.2	3	3	3	3
403.3	3	3	3	3
403.4	3	3	3	3
Average	3	3	3	3

Elective
M.Sc. (Biochemistry) Semester – IV
Paper: BCH – 404A
Pharmacovigilance and Clinical Trials

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions and covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. The candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To familiarize student about the Pharmacovigilance and Clinical Trials

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

404A.1 Understand the Basics and Terminology of Adverse drug reactions and importance of Clinical Therapeutics.

404A.2 Learn about Pharmacovigilance and Clinical Trials.

404A.3 Understand the Pharmacovigilance System & Regulations and Pharmacovigilance-Sources of ADRs (ICSRs).

404A.4 Learn about MedDRA and Pharmacovigilance Risk Management.

SECTION – A

Adverse Drug Reactions (ADRs) and Clinical Therapeutics: Basics and Terminology representing Adverse drug reactions, Types of ADRs, Seriousness and severity in ADR, Causality assessment of ADR, Difference in Expectedness and labelledness, PV plans-National, EMA, FDA, Significance and Importance of ADR reporting, Clinical Therapeutics: Basics and Its Importance

SECTION – B

Pharmacovigilance and Clinical Trials: Overview of Pharmacovigilance, Standard Terms And Terminology in Pharmacovigilance, Introduction of Clinical Research, Clinical trials: bioethics of drug safety, pharmacovigilance in trial design, applications for marketing authorization, Clinical Trial Phases, Drug Development and Launch, Importance of pharmacovigilance in Clinical Trials-Outcome and clinical implications, Pharmacological Principal of Clinical Research

SECTION – C

Pharmacovigilance System & Regulations: ICH: Basics and its Importance GVP Guidelines, ICMR, 21 CFR, CIOMS and its importance, NPP (National Pharmacovigilance Program) programmes in India, Awareness regarding NPP programmes

Pharmacovigilance-Sources of ADRs (ICSRs): Adverse Event Reporting System and Form, Adverse event reporting-Globally, Adverse event reporting in India, Sources of ADRs: Clinical trial, spontaneous, literature and NIP/NIS, Current status and knowledge about ADR reporting, Carrier opportunities as Affiliates

SECTION – D

MedDRA: History and Structure, MedDRA browser, versioning and updating, terminologies used in MedDRA, MedDRA coding, MedDRA baskets, Use of MedDRA in PV databases, Importance of having Global MedDRA terminologies

Pharmacovigilance Risk Management: Introduction, Aim of the RMP, Risk management cycle, Characterization of risks, RMP content and contributors, RMP review process, EU RMP versus Core RMP

Suggested readings:

1. Textbook of Pharmacoepidemiology, Edited by Brian L. Storm and Stephen K. Kimmel; Wiley Blackwell;5th Edition
2. Pharmacovigilance by Ronald D. Mann, Elizabeth Andrews; Wiley Blackwell;3rd Edition
3. Principles and practice of Clinical Research by John. I Gallin.; Academic Press;3rd Edition
4. Principles and practice of clinical trial medicine by Richard Cin and Bruce Y. Lee; Academic Press; 1st Edition

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO mapping matrix for BCH 404A (Pharmacovigilance and Clinical Trials)

Cos	PO1	PO2	PO3	PO4	PO5	PO6
BCH 404A.1	3	2	3	2	-	3
404A.2	3	1	3	1	-	3
404A.3	3	-	3	1	-	3
404A.4	3	-	3	1	-	3
Average	3	0.75	3	1.25	-	3

CO-PSO mapping matrix for BCH 404A (Pharmacovigilance and Clinical Trials)

Cos	PSO1	PSO2	PSO3	PSO4
BCH 404A.1	3	2	3	3
404A.2	3	2	3	3
404A.3	3	2	3	3
404A.4	3	2	3	3
Average	3	2	3	3

Elective
M.Sc. (Biochemistry) Semester - IV
Paper: BCH – 404B
Genetics and Evolution

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 3 hrs
Credits: 4

Note: The examiner will set nine questions in all with two questions from each section. Q. No. 1 consisting of very short answer type questions covering the entire syllabus will be compulsory. Each question will be divided into parts and the distribution of marks will be indicated part-wise. Candidates will be required to attempt Q. No. 1 & four others, selecting one from each section.

Objectives:

- To review the genetic basis of heredity for both Mendelian and quantitative characters
- To review the scientific evidence for biological evolution
- To explore how selection influences the genetic composition of a population
- To review the current understanding of how species are originated and how biological diversity arises

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

404B.1 Understand the mechanisms of heredity and evolution, and their consequences for population genetic structure and biodiversity

404B.2 Gain insight knowledge of transmission of hereditary characters

404B.3 Understand the fundamentals of population genetics

404B.4 Get the insight knowledge of genetic and ecological processes in the biological evolution

SECTION- A

Inheritance: Mendelian principles; extensions of Mendelian principles (codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance, expressivity and phenocopy); cytoplasmic inheritance; concept of gene; allele (multiple and pseudo); linkage; sex linked inheritance, mutations and recombination.

SECTION - B

Human Genetics: Human karyotype: banding and nomenclature of banding and aberrant karyotypes; Common syndromes due to numerical chromosome changes (triploidy, trisomy, monosomy) and structural alterations (translocation, duplications, deletions and fragile sites); Linkage map and Pedigree analysis; Identification of human genetic diseases- positional cloning illustrated using examples- Duchenne muscular dystrophy, cystic fibrosis, Huntington's disease.

SECTION - C

Evolutionary Thoughts and History: Lamarckism and Darwinism; Adaption, Struggle, Fitness and natural selection; The evolutionary synthesis; The evolutionary time scales; Eras, periods and epoch; Origins of unicellular and multicellular organism; Major groups of plants and animals; Stages in primate evolution including Homo.

SECTION - D

Molecular Evolution: Concept of neutral evolution, origin of new genes and proteins (by gene disruption and exon shuffling); gene duplication and divergence; variation (phenotypes, chromosome structure, protein structure and nucleotide sequences); speciation, allopatry and sympatry; isolating mechanisms; convergent evolution; co-evolution; adaptive radiation. **Population Genetics:** Populations, Gene pool, Gene and allele frequency; Conservation of gene frequency; Hardy Weinberg Law; concepts of rate of change in gene frequency through natural selection; random genetic drift.

Suggested readings:

1. Essential genes (2006), Benjamin Lewin, Pearson education international.
2. Human Molecular Genetics (2010), 4th ed., Tom Strachan and Andrew P Read, Garland Science.
3. Molecular Biology of Gene (2008), 6th ed., Watson, Baker *et al*, Levine and Losick, Pearson education Inc.
4. Principles of Genetics (2006), 8th ed., Gardner *et al*, John Wiley, New York.
5. Essential Genetics: A Genomic Perspective (2002), 3rd ed., Hart and Jones, Jones and Bartlett.
6. Genetics: Conceptual approach (2003), Benjamin A P, W H Freeman and Company, New York.
7. Principles of Genetics (2015), 7th ed., Snustad and Simmons, Wiley

Teaching Learning Process:

- Teaching is supported by Classroom Lectures, Power point presentations/ICT and related videos.
- Written assignments are assigned.
- Knowledge of the students is assessed through Oral test/surprise tests/ internal assessments.

CO-PO mapping matrix for BCH 404B (Genetics and Evolution)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 404B.1	3	3	-	2	-	1
404B.2	3	3	-	2	-	1
404B.3	3	3	-	2	-	1
404B.4	3	3	-	2	-	1
Average	3	3	-	2	-	1

CO-PSO mapping matrix for BCH 404B (Genetics and Evolution)

COs	PSO1	PSO2	PSO3	PSO4
BCH 404B.1	3	3	3	3
404B.2	3	3	3	3
404B.3	3	3	3	3
404B.4	3	3	3	3
Average	3	3	3	3

(Core)
M.Sc. (Biochemistry) Semester - IV
Paper: BCH –405
Practical-7 (Based on papers BCH-401 and BCH-402)

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 8hrs
Credits: 4

Course outcomes:

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

- 405.1 Demonstrate the proficiency in concepts, practical skills in biotechniques
- 405.2 An understanding of cytotoxic and cell staining assays
- 405.3 Develop skills in carrying out research projects in Gene cloning technology
- 405.4 Understand gene expression and purification system

List of experiments*

1. Western blotting
2. Cytotoxicity assays
3. Cell staining assays
4. To demonstrate Southern blotting and Northern blotting
5. To demonstrate Flow cytometry and Data analysis
6. Separation of poly RNA on oligodT column
7. To demonstrate preparation of *E. coli* competent cells and bacterial transformation
8. Isolation of Plasmid DNA
9. Digestion of vector using restriction enzymes
10. Ligation of vector and insert
11. Screening of recombinant colonies using Colony PCR.
12. Construction of restriction map of plasmid DNA
13. Gene Expression in *E. coli*
14. Purification of protein using His-Tag
15. Subcellular fractionation of organelles from animal/plant tissue

*As per feasibility of practical(s), teacher concerned may conduct additional practical(s) in addition to the present list, which will also be the part of syllabus for evaluation.

CO-PO mapping matrix for BCH 405 (Practical-7)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH 405.1	2	2	-	2	-	3
405.2	2	2	-	2	-	3
405.3	3	2	-	2	-	3
405.4	3	2	-	2	-	3
Average	2.5	2	-	2	-	3

CO-PSO mapping matrix for BCH 405 (Practical-7)

COs	PSO1	PSO2	PSO3	PSO4
BCH 405.1	3	3	3	3
405.2	3	3	3	3
405.3	3	3	3	3
405.4	3	3	3	3
Average	3	3	3	3

Core
M.Sc. (Biochemistry) Semester - IV
Paper: BCH –406
Practical-8 (Based on papers BCH-403 and BCH-404A & B)

Total Marks: 100
External Marks: 80
Internal Assessment: 20

Time allowed: 8hrs
Credits: 4

Course outcomes:

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

- 406.1 Demonstrate the proficiency in concepts, practical skills in bioinformatics
- 406.2 Understand Designing of primers using bioinformatics
- 406.3 Understand Homology modelling and 3D- structure determination of proteins
- 406.4 Demonstrate molecular docking experiments

List of experiments*

1. PubMed Search
2. Search and download gene sequence from GenBank
3. Search and download protein sequence from Uniprot/Swissprot
4. BLAST analysis
5. GeneTranslator
6. Finding of ORF in a given sequence
7. Designing of primers using bioinformatics
8. Sequence alignment using ALIGN and multiple sequence alignment using bioinformatics
9. 3D- structure determination of proteins
10. Retrieval of sequence using ENTREZ
11. To draw phylogenetic tree and its analysis
12. To demonstrate Lipinski's rule of five and ADME
13. Molecular docking analysis
14. Molecular Visualization Tools
15. Molecular signalling pathways analysis
16. To understand the linkage dis-equilibrium between genes
17. To understand the Hardy Weinberg equilibrium in a population

*As per feasibility of practical(s), teacher concerned may conduct additional practical(s) in addition to the present list, which will also be the part of syllabus for evaluation.

CO-PO mapping matrix for the course BCH-406 (Practical-8)

COs	PO1	PO2	PO3	PO4	PO5	PO6
BCH-406.1	3	3	3	-	3	3
BCH-406.2	3	3	3	-	3	3
BCH-406.3	3	3	1	2	3	3
BCH-406.4	3	3	1	-	2	3
Average	3	3	0.75	0.75	2.75	2.5

CO-PSO mapping matrix for the course BCH-406 (Practical-8)

COs	PSO1	PSO2	PSO3	PSO4
BCH-406.1	3	2	3	3
BCH-406.2	3	2	3	3
BCH-406.3	3	2	3	3
BCH-406.4	3	2	3	3
Average	3	2	3	3

CO-PO-PSO Mapping Matrix for all the courses of M.Sc. Biochemistry

Course Code	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3	PSO4
BCH-101	3	3	-	2	-	2	3	3	3	3
102	3	3	-	1.25	3	2.25	3	3	3	3
103	2.75	1	1.25	2	-	1	2.5	2.75	2.5	2.25
104	3	3	-	2.25	1	1.5	3	3	3	2
105	3	2.25	0.75	0.5	1.5	2.5	3	3	2	1.25
106	3	3	2	2	-	2	3	3	3	3
201	2.25	0.75	3	3	3	3	3	3	3	3
202A	3	3	0.75	2	1.75	2.5	3	3	3	2
202B	3	1.25	0.75	-	1.5	1.5	3	3	2.5	1.75
203	2.5	2.25	0.5	0.75	0.5	0.75	2.75	2.75	2.5	2.5
204	1.5	2.75	0.25	1.25	1	-	2.5	2.75	2.75	2.25
205	3	3	0.5	-	3	-	3	3	3	1
206	3	3	1	1	3	3	3	3	3	2
207	3	2	2	3	-	3	3	3	3	3
301	1.75	2.25	0.25	0.75	0.5	0.75	2.75	2.5	2.5	2.25
302	1.5	2.75	-	1.25	0.75	0.5	2.75	2.75	2.25	2.5
303	3	3	-	1.25	1.25	1.5	3	3	3	1.5
304	3	3	2.25	2	2.25	2.75	3	3	3	2
305	3	3	2.66	2.66	1.66	-	3	3	2	2.33
306	3	3	-	2	1	2	2	3	2	2
306A	3	3	3	3	2	3	3	3	3	3
307	3	3	2	3	-	3	3	3	3	3
308	3	3	2.25	2.25	2.75	2.5	3	3	3	2
401	2.75	0.5	1.75	1	0.5	1.5	2.75	2.5	2.5	1.75
402	3	2	1.5	2	-	2	2.75	2.75	3	3
403	3	2	-	1.75	-	2.5	3	3	3	3
404A	3	0.75	3	1.25	-	3	3	2	3	3
404B	3	3	-	2	-	1	3	3	3	3
405	2.5	2	-	2	-	3	3	3	3	3
406	3	3	0.75	0.75	2.75	2.5	3	2	3	3