FOUR YEAR UNDERGRADUATE (FYUG) PROGRAMME UNDER NATIONAL EDUCATION POLICY 2020

BIOCHEMISTRY

NORTH-EASTERN HILL UNIVERSITY,
SHILLONG

Preface:

A Bachelor of Science (B.Sc.) program in Biochemistry typically offers a comprehensive introduction to the fundamental principles and concepts of biochemistry, which is the study of chemical processes and substances that occur within living organisms. These courses provide a foundation into the core principles of biochemistry, such as the structure and function of biomolecules (proteins, carbohydrates, lipids, and nucleic acids), enzyme kinetics, metabolic pathways, and the regulation of biochemical processes. Practical laboratory sessions are often a significant component of the program. Students will gain hands-on experience in techniques used to study biomolecules, such as protein purification, chromatography, electrophoresis, spectroscopy, and molecular biology techniques like PCR (Polymerase Chain Reaction). They will also understand the structure and function of cells is crucial in biochemistry. Courses in cell biology will cover topics such as cell structure, organelles, cell signaling, and cellular processes like membrane transport and cell division. Learn about the molecular basis of inheritance, gene expression, DNA replication, transcription, and translation. This knowledge is essential for understanding how genetic information is utilized within cells and organisms. Explore the application of biochemistry in various fields, including medicine, agriculture, biotechnology, pharmaceuticals, and environmental science. This may include discussions on topics like drug design, bioremediation, and genetic engineering.

Program Outcomes (POs):

Program outcomes in biochemistry programs typically encompass a range of knowledge, skills, and competencies that students are expected to achieve by the time they complete their studies.

1. Students will be able to demonstrate a solid understanding of fundamental biochemical principles, including the structure and function of biomolecules, enzyme kinetics, metabolic pathways, and cellular processes.

2. Students will be proficient in laboratory techniques commonly used in biochemistry research and industry, such as protein purification, chromatography, electrophoresis, spectroscopy, and molecular biology techniques.

3. Able to critically analyze scientific literature, design experiments, and troubleshoot experimental procedures. They should also be able to apply biochemical principles to solve complex biological problems.

4. Students will be able to collect, analyze, and interpret experimental data using statistical and computational methods. They should also be proficient in using bioinformatics tools for the analysis of biological data.

5. Students will be able to effectively communicate scientific concepts and research findings through written reports, oral presentations, and scientific posters. They should also be able to collaborate with peers and communicate their ideas clearly in a team setting.

6. Students will understand the ethical considerations and responsibilities associated with conducting scientific research and working in the field of biochemistry. They should adhere to professional standards of conduct and integrity in their work.

7. They will have a broad understanding of how biochemistry intersects with other disciplines, such as biology, chemistry, genetics, and medicine. They should be able to integrate knowledge from multiple fields to address complex scientific questions.

8. Students will be prepared for careers in research, academia, industry, healthcare, and other related fields.

1st Semester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BCH-100	Introductory Biochemistry (Major)	3	1	4	75
BCH-100	Introductory Biochemistry (Minor)	3	1	4	75
MDC-110-119	Any of the available course as notified by the University from time to time	3		3	45
AEC-120-129	Any of the available course as notified by the University from time to time	3		3	45
SEC-130-139	Any of the available course as notified by the University from time to time	3		3	45
VAC-140	Environmental Science	3		3	45
	TOTAL	18	2	20	330

2ndSemester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BCH-150	Biomolecules (Major)	3	1	4	75
BCH-150	Biomolecules (Minor)	3	1	4	75
MDC-160-169	Any of the available course as notified by the University from time to time	3		3	45
AEC-170-179	Any of the available course as notified by the University from time to time	3		3	45
SEC-180-189	Any of the available course as notified by the University from time to time	3		3	45
VAC-190-199	Any of the available course as notified by the University from time to time	3		3	45
	TOTAL	18	2	20	330

BCH-Biochemistry; MDC-Multidisciplinary course; AEC-Ability Enhancement Course; SEC-Skill Enhancement Course; VAC-Value Added Course; VTC-Vocational Education and Training Course; 1 Credit = 25 marks.

3rd Semester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total Credits	
BCH-200	Protein and Enzymes (Major)	3	1	4	75
BCH -201	Techniques in Biochemistry (Major)	3	1	4	75
MDC-210-219	Any of the available course as notified by the University from time to time	3		3	45
AEC-220-229	Any of the available course as notified by the University from time to time	2		2	30
SEC-230-239	Any of the available course as notified by the University from time to time	3		3	45
VTC-240-249	Any of the available course as notified by the University from time to time	1	3	4	105
	TOTAL	15	5	20	375

VTC-Vocational Education and Training Course: 40 marks-Internal Test & 60 marks for the End Semester Examination; Out of 40 Internal marks-15 marks for Theory & 25 for Practical examinations. Similarly, out of 60 End semester marks-22.5 marks for Theory and 37.5 marks for Practical Examinations.

4thSemester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BCH -250	Thermodynamics & Membrane Chemistry (Major)	3	1	4	75
BCH -251	Cell Biology (Major)	3	1	4	75
BCH -252	Physiological Chemistry (Major)	3	1	4	75
BCH -253	Immunology (Major)	3	1	4	75
VTC-260-269	Any of the available course as notified by the University from time to time	1	3	4	105
	TOTAL	15	5	20	405

5th Semester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BCH -300	Microbiology (Major)	3	1	4	75
BCH -301	Intermediary Metabolism-I (Major)	3	1	4	75
BCH -302	Genetics & Molecular Biology-I (Major)	3	1	4	75
BCH -302	Intermediary Metabolism-I (Minor)	3	1	4	75
BCH -303	Internship (Major)		4	4	120
	TOTAL	12	8	20	420

6th Semester

Course Code	Course Title	Credits			Total Contact Hours
		Theory	Practical	Total	
BCH -350	Clinical Biochemistry (Major)	3	1	4	75
BCH -351	Molecular Biology - II (Major)	3	1	4	75
BCH -352	Biostatistics & Bioinformatics (Major)	3	1	4	75
BCH -353	Intermediary Metabolism - II (Major)	3	1	4	75
VTC-360-369	Any of the available course as notified by the University from time to time	1	3	4	105
	TOTAL	13	7	20	405

4. BIOCHEMISTRY

Programme in Biochemistry: A student will learn in-depth about how the chemical properties of molecules determine the ways in which they interact and react with each other in creating and sustaining life; there will be comprehensive teaching on enzymology, metabolism, structural biology, bioenergetics, molecular biology and genetic engineering leading to understanding of life as chemical process.

Programme Outcomes (POs): A biochemistry graduate will acquire exhaustive knowledge and understanding of biochemical reactions that he/she would be able to apply in research in fields of pharmacology, drug discovery, bioremediation, medicine, immunology, neurochemistry, endocrinology, etc. Other attributes gained from working in the laboratories would be hands-on training on scientific equipment, developing patience, learning to modify research protocols and being disciplined. There are ample job opportunities for a biochemistry graduate in higher studies, as academic researcher, analytical chemist, biomedical scientist, biotechnologist, clinical research associate, clinical scientist, forensic scientist, medicinal biochemist.

BCH-100: INTRODUCTORY BIOCHEMISTRY

(Contact Hours: 75, Credits: 4)

Course Objectives (COs):

1. To impart foundation in chemical nature of life
2. To clarify numerical concepts used in biochemistry
3. To teach concepts such as buffer, chemical bonds, functional groups and their importance
4. To relate the significance of biochemistry in everyday life

Learning Outcomes (LOs):

1. A graduate will have specific knowledge of biochemical concepts of origin and sustenance of life
2. Will be proficient in calculating strength/concentration of solutions and in preparing reagents and buffers
3. Will have a comprehensive knowledge of application of biochemistry in scientific fields such as agriculture, medicine, pharmaceutical, forensic science, nutrition and food processing, etc.

Unit I

Foundations of biochemistry: Physical foundations; chemical foundations; cellular foundations; distinguishing features of living organisms; energy source in living organisms

(chemotrophs and phototrophs); micromolecules and macromolecules; significance of *in vitro* and *in vivo* studies.

Historical perspective in biochemistry: Carl Neuberg, Lavoisier and oxidation of food, Wohler and synthesis of urea, Emil Fischer, Claude Bernard, Louis Pasteur and fermentation, Buchner Experiment, payen and diastase; Joseph Priestly and oxygen; Friedrich Miescher, Meyer and von Helmholtz, Hans Adolf Krebs, James B Sumner, Meyerhof and Hill, Miller-Urey Experiment.

Applications of biochemistry: Role of biochemistry in agriculture, medical science, pharmaceutical, nutrition and food processing, forensic science.

Unit II

Numerical concept: An overview on the metric system, atomic weight, molecular weight, equivalent weight, basicity of acids, acidity of bases, Avogadro's number, mole concept, percentage, molarity, molality, normality, Dalton concept, density, specific gravity, assay percentage, stock solution and working reagent, dilution factor, standard conditions in biological system.

Chemical bonds and common functional groups in biomolecules: Formation and properties of covalent bonds, non-covalent bonds (hydrogen bonds, ionic bonds, Vander Waals interactions, London forces, dipole-dipole interactions, electrostatic interactions and hydrophobic interactions), sigma, pi and co-ordinate bonds. versatility of carbon bonding in living organisms; some common functional groups in biomolecules.

Unit III:

Water and buffer: Biological significance of water, physical and chemical properties of water, colligative properties of water, molecular structure of water, ionization of water; ionic product of water, pH and pOH of water, water as a reactant, ultrapure water, deionized water, RO water, distilled water and double distilled water; buffer, pH and pKa, Henderson-Hasselbach equation, titration curve of weak acids, buffering capacity, buffering region, buffers in living organisms: phosphate buffer, bicarbonate buffer, proteins buffering ability.

Unit IV: Practical

1. Preparation of x gm/ml of Glucose and conversion into y M Glucose.
2. Preparation of 1MPotassium Dichromate and performing serial dilution of 0.1 M, 0.2 M,...to.., 0.9 M, 1M Potassium dichromate.
3. Calibration of pH meter.
4. Finding the pKa of Sodium acetate buffer.
5. Preparation of Buffer by Henderson-Hasselbalch Equation& Study on the Effect of different concentrations of buffer on the Buffering Capacity.
6. Titration Curve of acetic acid with NaOH.

Suggested readings:

1. Berg J M, John L, Stryer L (2012) Biochemistry 7th Ed., W H Freeman & Co. Ltd.
2. Garrett R H & Grisham C M (2012) Biochemistry 5th Ed., Brooks Cole Publ.
3. Harper's Illustrated Biochemistry 32nd Ed. (2022), Murray et al. McGraw Hill Publ.

4. Jayaraman (2011) Laboratory Manual in Biochemistry, New Age Int. Publ.
5. Nelson D L and Cox M M (2021) Lehninger's Principles of Biochemistry, Macmillan Publ.
6. Plummer D T (2008 reprint) An Introduction to Practicals in Biochemistry3rd Ed., Tata McGraw- Hill .
7. Powar C B & Chatwal G R , Biochemistry (2011), Himalaya Publishing House
8. Rosenberg J, Epstein L (2015) College Chemistry, McGraw Hill Education, India
9. Sadasivam S and Manickam A (2018) Biochemical Methods, 3rd Ed. New Age Int. Publ., New Delhi.
10. Segel Irwin H. (2010), Biochemical Calculations 2nd Ed., John Wiley & Sons.
11. Solomon T W G, Frhyle C B & Snyder S A (2016) Organic Chemistry 11th Ed., Wiley Madan R D (2018) Modern Inorganic Chemistry, S Chand Publ.
12. Voet D &Voet J G (2010) Biochemistry 4th Ed., John Wiley & Sons.
13. Zubay G (2020) Biochemistry 5th Ed., W C Brown Commun, Inc.

BCH-150: BIOMOLECULES

(Contact Hours: 75, Credits: 4)

Course Objectives (COs)

1. To understand the organization of simple molecules into macromolecular and supra molecular structure
2. To recall the Classification of Biomolecules
3. To compare the function of the various Biomolecules to sustain Life
4. To examine the role played by the functional groups and chemical bonds in Biomolecules
5. To estimate the concentration of Biomolecules

Learning Outcomes (LOs):

1. A graduate will have specific knowledge on the organization of monomers into macromolecular and supra molecular structure
2. Will be able to analyze the structure-function relation of a biomolecule
3. Will be able to estimate the amount of any biomolecule in a sample
4. Will be able to explain the importance of the various biomolecules to sustain Life

Unit I

Carbohydrates and sugars: Properties, structure and classification of monosaccharides (glucose & fructose), disaccharides (sucrose, maltose and lactose) and polysaccharides (dextrins, starch, glycogen and cellulose); glycosidic bonds, ketal, hemiketal, acetal and hemi acetal, reducing and non- reducing sugars; Stereochemistry of sugars: chiral carbon, epimers, anomers, mutarotation, chair and boat forms, glycosides, glucopyranose and fructopyranose; Fischer projection, Haworth projection; ABO blood group.

Fatty acids and lipids: Fatty acids: nomenclature and chemical properties; Lipid classification: simple and complex; general structure and function of the major lipid sub-classes; acylglycerols, phosphoglycerides, sphingolipids, waxes and terpenes, steroids and prostaglandins; Supra molecular structure: lipid membrane.

Unit II

Amino acids and proteins: Alpha amino acids: structure and properties of amino acids; Proteins: primary structure (structure of peptide bond-restricted rotation, *cis/trans*); secondary structure (α, β and super secondary structures); tertiary structure and quaternary structure of proteins, Ramachandran plot.

Unit III

Nucleotides and nucleic acids: Nucleotides: chemistry and properties. Nucleic acids: double helical structure of DNA, different forms and function of DNA; Functions of RNA: mRNA, tRNA, rRNA, siRNA, miRNA; Supra molecular complexes: chromosomes & ribosomes.

Application of spectrophotometry in the analysis of biomolecules: Absorption of UV-Vis light by biomolecules & spectral analysis, maximal wavelength of absorbance, Beer-Lambert's Law, instrumentation of spectrophotometer, chromogen, concept of blank, glass cuvette, quartz cuvette.

Unit IV: Practical

1. Verification of Beer-Lambert's Law
2. Estimation of amino acid using ninhydrin
3. Estimation of protein by Lowry's method
4. Estimation of protein by Bradford's method.
5. Estimation of DNA using diphenylamine
6. Estimation of RNA using orcinol
7. Estimation of Carbohydrates by Anthrone's Method
8. Estimation of Cholesterol by Zak's Method

Suggested readings:

1. Berg J M, John L, Stryer L (2012) Biochemistry 6th Ed., W H Freeman & Co. Ltd.
2. Boyer R F (2009) Modern Experimental Biochemistry 3rd Ed., 5th Impression Pearson Educ.
3. Damodaran G (2011) Practical Biochemistry, Jaypee Bros. Publ.
4. Devlin T. M. (2010) Textbook of Biochemistry with Clinical Correlations 7th Ed., Wiley Publ.
5. Freifelder D (1983) Physical Biochemistry, W H Freeman.
6. Garrett R H & Grisham C M (2012) Biochemistry 5th Ed., Brooks Cole Publ.
7. Harper's Illustrated Biochemistry 32nd Ed. (2022), Murray et al. McGraw Hill Publ.
8. Jayaraman (2011) Laboratory Manual in Biochemistry, New Age Int. Publ.
9. Nelson D L and Cox M M (2021) Lehninger's Principles of Biochemistry, Macmillan Publ.

10. Nigam A & Ayyagiri A (2008) Lab Manual in Biochemistry, Immunology &Biotechnology, Tata McGraw Hill.
11. Plummer D T (2008 reprint) An Introduction to Practicals in Biochemistry 3rd Ed., Tata McGraw- Hill Sambrook J and Russel D W (2012) Molecular Cloning 4th Ed., CSH Lab Press.
12. Rao B S & Deshpande V (2005) Experimental Biochemistry Students Companion I K International Publ.
13. Sadasivam S and Manickam A (2018) Biochemical Methods, 3rd Ed. New Age Int. Publ., New Delhi.
14. Voet D &Voet J G (2010) Biochemistry 4th Ed., John Wiley & Sons.
15. Wilson K and Walker J (2002) Principles and Techniques of Practical Biochemistry 5thEd. Cambridge Publ.
16. Yadav V. K. et al (2012) Biochemistry & Biotechnology- A Lab Manual, Pointer Publ.
17. Zubay G (2020) Biochemistry 5th Ed., W C Brown Commun, Inc.

3rd Semester

BCH-200	**Proteins & Enzymes**	**Total Credits: 4** **Total Contact Hours: 75** **Total marks: 100**

Course Objectives (COs):

1. To educate on the methods for protein isolation, purification together with sequencing
2. To acquaint about enzymes – their properties and classification
3. To familiarize about the concepts of activation energy, and also mechanism of enzyme action and regulation
4. To learn about enzyme kinetics and inhibition

Learning Outcomes (LOs):

1. A graduate will have an understanding about the nature and importance of enzymes in living systems
2. Will have a deeper insight of enzyme kinetics and appreciate how enzymes catalyze reactions
3. Will be able to carry out protein purification and enzyme-based experiments

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

Protein isolation and purification techniques (salt precipitation, dialysis and chromatography). Criteria for protein purity and homogeneity; protein sequencing; Protein folding, Protein turnover & Protein Targeting.

Unit II:

Enzymes: properties (enzyme activity & specific enzyme activity) and classification (IUB enzyme classification and nomenclature system). Enzyme-substrate (ES) complex: concept of substrate binding sites and active sites, significance of activation energy and free energy. Factors affecting enzyme activity; coenzymes (Pyridoxal phosphate, NAD^+ & FAD^+) & cofactors. Mechanism of enzyme catalysis (chymotrypsin & lysozyme).

Unit III:

Michaelis-Menten equation: derivation, significance of *Vmax*, *kcat* and *Km*. Lineweaver- Burk Plot, Eadie- Hofstee plot.
Enzyme inhibition: competitive, non-competitive and uncompetitive. Regulation of enzyme activity: allosteric regulation, covalent modification and zymogenicity.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Gel filtration chromatography using protein mixture or dye
2. Estimation of catalase activity
3. Assay of urease/ amylase activity
4. Determination of Km and Vmax of urease/ amylase
5. Effect of pH, temperature and substrate concentration on enzyme activity

Suggested readings:

1. Bell J. E. et al (1988) Proteins & Enzymes, Prentice hall
2. Berg J M et al (2023) Biochemistry 10th Edn., Macmillan Pub.
3. Bohager Tom (2006) Enzymes: What Experts know? One World Press
4. Boyer R F (2009) Modern Experimental Biochemistry 3rd Edn. , 5th Impression Pearson Edn.
5. Damodaran G (2011) Practical Biochemistry, Pub Jaypee bros.
6. Effront J (2008) Enzyme & their Application, Kessinger Pubn.
7. Jayaraman (2011) Laboratory Manual in Biochemistry, New Age Int. Pub.
8. Kessel Amit (2011) Introduction to Proteins 1st Edn.CRC Press
9. McGraw Hill
10. Nelson D L and Cox M M (2021) Lehninger's Principles of Biochemistry, Macmillan Pub.
11. Nigam A & Ayyagiri A (2008) Lab Manual in Biochemistry, Immunology & Biotechnology, Tata
12. Palmer T (2007) Enzymes 2nd Edn. Ellis Horwood Ltd.
13. Plummer D T (2008 reprint) An Introduction to Practicals in Biochemistry 3rd Edn., Tata McGraw- Hill
14. Price N C (2009) Exploring Proteins, Oxford University Press
15. Rao B S &Deshpande (2005) Experimental Biochemistry Graduates Companion I K International Pub
16. Sadasivam S and Manickam A (2005) Biochemical Methods,(Rev Edn.) New Age Int. Pub, New Delhi.
17. Sambrook J and Russel D W (2012) Molecular Cloning 4th Edn., CSH Lab Press
18. Whitford D (2005) Proteins 1st Edn. Wiley
19. Williamson Mike (2011) How Proteins Work 1st Edn. Garland Science
20. Yadav V. K. et al (2012) Biochemistry & Biotechnology- A Lab Manual, Pointer Publns.

3rd Semester

BCH-201	**Techniques in Biochemistry**	**Total Credits: 4** **Total Contact Hours: 75** **Total marks: 100**

Course Objectives (COs):

1. To introduce the underlying principles and applications of the techniques of chromatography, centrifugation, microscopy and staining
2. To learn the fundamentals of radiochemistry and their applications in biology.

Learning Outcomes (LOs):

1. A graduate will have acquired the knowledge about the working principles and applications of the various techniques used in the biochemistry laboratory
2. Will have understood about radioisotopes – their detection and uses.
3. Will be able to perform sub-cellular fractionation and separate biomolecules using simple Chromatographic/ electrophoretic **t**echniques.

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

General principles of chromatography – adsorption and partition. Paper chromatography; Column chromatography; Gel filtration; Ion-exchange; Affinity chromatography& HPLC. Thin layer chromatography (TLC); Electrophoreses (Native and SDS PAGE).

Unit II:

Centrifugation; Differential and Density Gradient (isopycnic and rate zonal); Types of rotors & Ultra centrifuge.

Unit III:

Principle of Light microscope; Phase Contrast; Fluorescence; Confocal; Electron microscope; Staining techniques for microscopy studies.

α, β and γ radiation. Detection of radioactivity by Scintillation counting. Application of radio-isotopes in biology.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Separation of amino acids by TLC
2. Separation of carbohydrates by paper chromatography

3. Separation of amino acids by paper chromatography
4. Separation of proteins by SDS-PAGE

Suggested readings:

1. Biophysical Chemistry, Principles & Techniques (2020) – Upadhyay, Upadhyay and Nath –Himalaya Publ. House.
2. Irwin H. Segel, Biochemical Calculations (2010) 2nd Edn., John Wiley & Sons.
3. Jayaraman J (2011) Laboratory Manual in Biochemistry 2nd Edn, New Age Int. Publ.
4. Plummer D T (2008 reprint) An Introduction to Practical's in Biochemistry 3rd Edn.,Tata McGraw- Hill
5. Wilson and Walkers's Principles & Techniques of Practical Biochemistry (2018) 8th Edn, Cambridge Univ. Press.

4th Semester

BCH-250	**Thermodynamics & Membrane Chemistry**	**Total Credits: 4**
		Total Contact Hours: 75
		Total marks: 100

Course Objectives (COs):

1. To provide the basic understanding of classical thermodynamics principles in biology
2. To impart understanding on the concept of redox potential and phosphoryl transfer potential
3. To delve on the various types of membrane transporters

Learning Outcomes (LOs):

1. A graduate would have understood the energy transformations in biological systems
2. Will have understood the oxidation-reduction reactions
3. Will have comprehended the types of membrane transport mechanisms
4. Will have acquired the practical training to separate and estimate lipids

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:
First law of Thermodynamics; Heat of formation & Heat of reaction; Second law of Thermodynamics; Entropy; Gibbs free energy and derivation of $\Delta G'^{0} = -RT\ln keq'^{0}$.

Unit II:
Types of Electrodes, Cells: oxidation–reduction reaction, standard electrode potential and its determination, measurement of ΔG. Electron transfer measures and phosphate group transfer potentials. Coupled reactions and simultaneous equilibria.

Unit III:

Membrane chemistry: Prokaryotic, eukaryotic and subcellular membranes. Fluid mosaic model; Monolayer, planar bilayer and liposomes as model membrane systems. Membrane fluidity, factors affecting membrane fluidity. Active and Passive transport; Uniport, Symport and Antiport.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Separation of lipids by TLC
2. Estimation of phospholipids by Bartlet method
3. Determination of oxidizing / reducing potential of water sample using ORP electrode

Suggested readings:

1. Berg J M et al (2023) Biochemistry 10th Edn., Macmillan Pub.
2. Boyer R F (2009) Modern Experimental Biochemistry 3rd Edn. , 5th Impression Pearson edn.
3. Freifelder D (1982) Physical Biochemistry, W H Freeman.
4. Nelson D L and Cox M M (2021) Lehninger's Principles of Biochemistry, Macmillan Pub.
5. Wilson K and Walker J (2002) Principles and Techniques of Practical Biochemistry 5th Edn. Cambridge

4th Semester

BCH-251 **Cell Biology** **Total Credits: 4**
Total Contact Hours: 75
Total marks: 100

Course Objectives (COs):

1. To recall the concepts of basic structure and function of cells and subcellular organelles
2. To provide insights on the composition of cytoskeleton
3. To inform about the various cellular events
4. To impart knowledge on cell fractionation and cell visualization techniques

Learning Outcomes (LOs):

1. A graduate will have gained knowledge about basic cell structure of eukaryotes, prokaryotes and viruses
2. Will have grasped the concepts of cell cycle, cell division, cell death and causes of cancer
3. Will have gained experience in sample preparation techniques of fixation and staining and also in handling microscopes

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

Prokaryotes: Cell structure and components. Eukaryotes: Cell structure and subcellular organelles (plants and animal cells); Structure of viruses (bacteriophages & TMV)

Unit II:
Cell-cell interactions in plants and animals, Autophagy; types of phagocytosis, pinocytosis, exocytosis.

Unit III:
Cytoskeleton: microtubules and microfilaments; Cell motility- ciliary and flagellar movement, bacterial taxis. Cell division (mitosis & meiosis): Cell cycle and its regulation; Introduction to Apoptosis; Stem cells; Tumour & Cancer cells.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV: Practical

1. To make temporary squash preparation of grasshopper testis / onion flower buds and study the various stages of meiosis
2. To make temporary squash preparation of root tips and study the various stages of mitosis

3. Study on the mammalian cell and cancer cell using permanent slides
4. Isolation of nuclei by subcellular fractionation

Suggested readings:

1. Alberts B, Heald R, Johnson A, Morgan D. (2022) Molecular Biology of Cell 7th Edn., WW Norton & Co.
2. Barrett K E et. Al. (2009) Ganong's Review of Medical Physiology 23rd Edn. LANGE Basic Science
3. Berg J M et al (2023) Biochemistry 10th Edn., Macmillan Pub.
4. Bhagavan N V et. al. (2011)Essentials of Medical Biochemistry with Clinical cases 1st Edn., Acad.
5. Darnell J, Lodish H and Baltimore D (2016) Molecular Cell Biology 8th Edn., W H Freeman and co
6. Ganong W F (2003) Review of Medical Physiology 21st Edn. Appleton & Lange USA
7. Guyton A C & Hall (2010)Textbook of Medical Physiology 12th Edn., W B Saunders.
8. Karp Gerald (2009) Karp's Cell and Molecular Biology: Concepts and Experiments 9th Edn., Wiley Pubn.
9. Lodish H (2021) Molecular Cell Biology 9th Edn., Macmillan Pub.
10. Physiology & Biochemistry in Modern Medicine (2012) by Books Group, General Books Pbn.
11. Weaver R (2011) Molecular Biology 5th Edn., McGraw Hill Sc.
12. Wilson K and Walker J (2002) Principles and Techniques of Practical Biochemistry 5th Edn. Cambridge

4th Semester

BCH-252	**Physiological Chemistry**	**Total Credits: 4** **Total Contact Hours: 75** **Total marks: 100**

Course Objectives (COs):

1. To learn about the basic physiological principles of homeostasis, digestion and absorption, gaseous exchange in respiration, muscle contraction, vision, urine formation and circadian cycle
2. To learn basic physiological chemistry experiments

Learning Outcomes (LOs)

1. A graduate will have understood the basic organization and homeostatic control existing in an animal body
2. Will be able to perform physiological experiments related to SpO2, haemoglobin, RBC and WBC count

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

Homeostasis; Gut-microbiota and its significance in human health; Digestion, absorption and transport of carbohydrates, lipid, proteins and nucleic acids. Absorption and transport of minerals (Fe^{2+} and Ca^{2+}) and vitamins (C & D). Blood cells; Respiration-oxygen and carbon dioxide transport; regulation of respiration; Blood clotting.

Unit II:

Excretion (Formation of urine, regulation of water, electrolyte balance, role of hormones in its maintenance). Impulse transmission; Skeletal muscle contraction; Biochemistry of Vision.

Unit III:

Introduction to Circadian cycle; Senescence & aging; Uterine changes (menstrual cycle, fertilization and implantation).

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Estimation of haemoglobin
2. Estimation of Calcium

3. RBC count
4. Differential WBC count
5. SpO_2 determination

Suggested readings:

1. Alberts et al. (2022) Essentials Cell Biology 7th Edn., WW Norton & Co.
2. Betts J G et al., (2022) Anatomy and Physiology, 2nd Edn, OpenStax Rice University Pub.
3. Bhagavan N V et. al. (2011) Essentials of Medical Biochemistry with Clinical cases 1st Edn., Acad.
4. Boyer R F (2009) Modern Experimental Biochemistry 3rd Edn. , 5th Impression Pearson edn.
5. Damodaran G (2011) Practical Biochemistry, Pub Jaypee bros.
6. Darnell J, Lodish H and Baltimore D (2016) Molecular Cell Biology 8th Edn., W H Freeman and co.
7. Ganong W F (2019) Review of Medical Physiology 26th Edn. McGraw- Hill
8. Guyton A C & Hall (2020) Textbook of Medical Physiology 14th Edn., Elsevier.
9. Hardin J (2018) Becker's World of the Cell, 9th Edn. Pearson Pub.
10. Jayaraman (2011) Laboratory Manual in Biochemistry, New Age Int. Pub.
11. Karp Gerald (2009) Molecular cell Biology 6th Edn., Wiley Pubn.
12. McLeod J R and Pearce R G (2022) Physiology And Biochemistry In Modern Medicine, Legare Street Press
13. Nigam A & Ayyagiri A (2008) Lab Manual in Biochemistry, Immunology & Biotechnology, Tata
14. Physiology & Biochemistry in Modern Medicine (2012) by Books Group, General Books Pbn.
15. Plummer D T (2008 reprint) An Introduction to Practicals in Biochemistry 3rd Edn., Tata McGraw- Hill
16. Yadav V. K. et al (2012) Biochemistry & Biotechnology- A Lab Manual, Pointer Publns.

4th Semester

BCH-253 **Immunology** **Total Credits: 4**

Total Contact Hours: 75
Total marks: 100

Course Objectives (COs):

1. To apprise about the basic components and functions of the immune system
2. To learn the structure and functions of immunoglobulins; together with the nature of antigens
3. To understand the mechanism of hypersensitivity, autoimmunity and graft rejection; and the types of vaccines

Learning Outcomes (LOs):

1. A graduate will have understood the overall concept of immune system
2. Will be competent enough to carry out common immunology-based experiments

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:
Concept of immunity: innate and adaptive immunity; Cells and Organs of the immune system; Immunoglobulins- structure and functions; classes of antibodies: Antigens- Nature of antigens; Antigen- antibody interactions; Immunogens; Haptens; Adjuvants; ELISA.

Unit II:
Haematopoietic stem cells; clonal selection theory; Genetic basis of antibody diversity: Complement system and activation pathways; Complement fixation test: Hypersensitivity: Autoimmune diseases; Monoclonal antibody and its application.

Unit III:
Structure and functions of MHC molecules; Immunological basis of graft rejection; immunosuppressive therapy; Vaccines.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:
1. Histological study of spleen, thymus and lymph nodes through slides/ photographs
2. Determination of ABO blood groups and Rh factor
3. Determination of Ag-Ab patterns using Ouchterlony Double Diffusion Method
4. Quantification of antigen using radial immunodiffusion

Suggested readings:

1. Alberts et al. (2022) Essentials Cell Biology 7th Edn., WW Norton & Co.
2. Boyer R F (2009) Modern Experimental Biochemistry 3rd Edn. , 5th Impression Pearson edn.
3. Damodaran G K (2011) Practical Biochemistry, Pub Jaypee bros.
4. Divya Santhi (2010) An Easy Guide for Practical Biochemistry, Jaypee brothers & Medical Publn.
5. Farrell et al (2005) Experiments in Biochemistry: A Hands-on Approach 2nd Edn. Brooks Cole Pbn.
6. Gupta B (2010) Practical Biochemistry, CBS Publishers
7. Jayaraman (2011) Laboratory Manual in Biochemistry, New Age Int. Pub.
8. Khanna Raj (2011) Immunology, Oxford University Press
9. Male D K (2012) Immunology 8th Edn. Elsevier.
10. Murphy (2017) Immunobiology 9th Edn. WW Norton & Co
11. Nigam A & Ayyagiri A (2008) Lab Manual in Biochemistry, Immunology & Biotechnology, Tata
12. Plummer D T (2008 reprint) An Introduction to Practicals in Biochemistry 3rd Edn., Tata McGraw- Hill
13. Rao B S & Deshpande (2005) Experimental Biochemistry Graduates Companion I K International Pub
14. Roitt I M, Burton D R et al (2017) Essential Immunology 13th Edn. Wiley Blackwell Pbn.
15. Sadasivam S and Manickam A (2022) Biochemical Methods,4th Edn., New Age Int. Pub, New Delhi.
16. Sawhney S K. (2005) Introductory Practical Biochemistry, Alpha Science International Ltd.
17. Thomas J et al (2018) Kuby Immunology 8th Edn. W H Freeman
18. Yadav V. K. et al (2012) Biochemistry & Biotechnology- A Lab Manual, Pointer Publns.

5th Semester

BCH-300 **Microbiology** **Total Credits: 4**
Total Contact Hours: 75
Total marks: 100

Course Objectives (COs):

1. To introduce classification systems used for microorganisms
2. To learn the basic microbial culture techniques
3. To educate on the concepts of microbial growth and mechanisms for their control
4. To acquire a comprehensive understanding of microbial genetics
5. To understand the positive and negative aspects of microbes

Learning Outcomes (LOs):

1. A graduate would have learnt classification systems used for microorganisms
2. Would have learnt basic microbial culture techniques
3. Would have comprehended the concepts of microbial growth and mechanisms for their control
4. Would have acquired an understanding about microbial genetics
5. Would have understood the positive and negative aspects of microbes

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

Introduction to microbiology: Evolution of microorganisms and microbiology: Classification of microorganism (Five Kingdom and Three Domain); criteria use in the classification of bacteria.
Methods of microbiology: Pure Culture techniques (Isolation of pure culture by plating methods and liquid media); Theory and Practice of Sterilization: Sterilization by heat, chemical treatment and filtration.
Microbial Nutrition: Requirement for Carbon, Sulfur and Growth Factors, role of oxygen in nutrition. Nutritional categories among microorganisms (Photoautotrophs, Photoheterotrophs, Chemoautotrophs and Chemoheterotrophs)

Unit II:

Culture Media: Complex and chemically defined media, selective and differential media.
Microbial Growth: Definition of Growth, mathematical nature and expression of growth, growth curve. Measurement of growth (cell mass, cell number and cell constituent); synchronous growth; batch culture and continuous culture.

Unit III:

Role of microorganisms in Food Spoilage; Food-borne infections; Probiotics, cheese production
Microbial Genetics: transformation, conjugation, transduction and transfection; Plasmids, transposable elements; phage genetics, lysogenic and lytic.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Isolation of microbes from water and soil using selective media
2. Study of bacterial growth curve
3. Effect of antibiotics on bacterial growth
4. Isolation of pure culture: spread plate and pour plate methods
5. Gram staining of bacteria

Suggested readings:

1. Boyer R F (2009) Modern Experimental Biochemistry 3rd Edn. , 5th Impression Pearson edn.
2. Brown A E (2011) Benson's Microbiological Application 12th Edn. McGraw Hill
3. Burton, Leboffe et al (2012) Photographic Atlas for Microbiology 4th Edn.Morton Pbn.
4. Cappuccino J G, Welsh C (2023) Microbiology: A Laboratory Manual 11th Edn., Pearson
5. Damodaran G K (2011) Practical Biochemistry, Pub Jaypee bros.
6. Divya Santhi (2010) An Easy Guide for Practical Biochemistry, Jaypee brothers & Medical Publn.
7. Farrell et al (2005) Experiments in Biochemistry: A Hands-on Approach 2nd Edn. Brooks Cole Pbn.
8. Gupta B (2010) Practical Biochemistry, CBS Publishers
9. Jayaraman (2011) Laboratory Manual in Biochemistry, New Age Int. Pub.
10. Nester E W (2003) Microbiology 4th Edn. McGraw Hill
11. Nigam A &Ayyagiri A (2008) Lab Manual in Biochemistry, Immunology & Biotechnology, Tata
12. Plummer D T (2008 reprint) An Introduction to Practicals in Biochemistry 3rd Edn., Tata McGraw- Hill
13. Presscott L M et al (2004) Microbiology 6th Edn, McGraw Hill
14. Rao B S &Deshpande (2005) Experimental Biochemistry Graduates Companion I K International Pub
15. Sadasivam S and Manickam A (2005) Biochemical Methods,(Rev Edn.) New Age Int. Pub, New Delhi.
16. Sawhney S K. (2005) Introductory Practical Biochemistry, Alpha Science International Ltd.
17. Sherman C (2004) Microbiology A Laboratory Manual 6th Edn, Pearson Education
18. Talaro K P (2011) Foundations in Microbiology 8th Edn. McGraw Hill
19. Tortora G, Funke B, Case C. et al (2020) Microbiology: An Introduction 13th Edn., Pearson
20. Willey J et al (2010) Presscott's Microbiology 8th Edn. McGraw Hill
21. Wood D, Willey J, Sandman K (2022) Prescott's Microbiology 12th Edn., McGraw Hill
22. Yadav V. K. et al (2012) Biochemistry & Biotechnology- A Lab Manual, Pointer Publns.

5th Semester

BCH-301 **Intermediary Metabolism-I** **Total Credits: 4**
Total Contact Hours: 75
Total marks: 100

Course Objectives (COs):

1. To develop a thorough knowledge among the graduates about metabolism
2. To learn the fate of dietary carbohydrates, proteins and lipids
3. To enable graduates in visualizing energy production and utilization in biological processes
4. To study the interrelationship between carbohydrate, protein and fat metabolism

Learning Outcomes (LOs):

1. Graduates shall be able to understand the concept of anabolism and catabolism of biomolecules and role of high energy compounds in the cell
2. Will understand the interrelations and regulations of the pathways associated with carbohydrates, proteins and lipids metabolism
3. Will be able to isolate glycogen from animal tissues
4. Will be able to assay metabolic enzyme activity

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

Introduction to metabolism (Catabolic, Anabolic & Amphibolic): Carbohydrate metabolism; Glycolysis & its regulation; Warburg effect and Alcoholic fermentations; TCA cycle & its regulation; Gluconeogenesis, Glycogenesis, Glycogenolysis and their regulations; pentose phosphate pathway, Glyoxylate pathway.

Unit II:

Lipid Metabolism: Shuttle of fatty acids into mitochondria, β-oxidation of saturated fatty acids, oxidation of unsaturated and odd chain fatty acids, ATP yield from fatty acid oxidation vis-à-vis Glucose. Biosynthesis of saturated and unsaturated fatty acids. Biosynthesis and regulation of triglycerides and cholesterol.

Unit III:

Amino acid Metabolism: General reactions of amino acid metabolism: transamination, oxidative deamination and decarboxylation. Urea cycle. Biosynthesis of amino acids (Glutamine, tryptophan and Histidine). Degradation of amino acids.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Estimation of urea
2. Isolation and estimation of glycogen from animal tissues
3. Assay of GOT from tissue samples
4. Assay of GPT from tissue samples

Suggested readings:

1. Berg J M, Gatto Jr. G J, Hines J, Tymoczko J L (2023) Biochemistry 10th Edn., W.H.Freeman
2. Davies David D (2011) Intermediary Metabolism in Plants, Cambridge University Press.
3. Devlin T. M. (2010) Textbook of Biochemistry with Clinical correlations 7th Edn., Wiley Pubn.
4. Gareth & Grisham (2008) Biochemistry 4th Edn., Brooks Cole Pbn.
5. Grisham C, Garrett R (2016) Biochemistry 6th Edn., Brooks Cole Pbn.
6. Harper's Illustrated Biochemistry 29th Edn. (2012) , Murray et al. McGraw Hill Pubn.
7. Harris D A (2009) Bioenergetics at a Glance-An Illustrated Introduction, Blackwell Sci. Pub.
8. Nelson D L and Cox M M (2021) Lehninger Principles of Biochemistry 8th Edn., W.H.Freeman
9. Nicholls D G et al (2002) Bioenergetics 3rd Edn., Academic Press.
10. Ochs R S (2022) Biochemistry 2nd Edn., CRC Press
11. Rai A N (1990) handbook of Symbiotic Cyanobacteria, CRC Press
12. Rawn J D (2005) Biochemistry 4th Edn., Prentice Hall
13. Voet D &Voet J G (2004) Biochemistry 3rd Edn., John Wiley & Sons.
14. Zubay G (1999) Biochemistry 4th Edn., W C Brown Commun, Inc.

5th Semester

BCH-302 **Genetics & Molecular Biology-I** **Total Credits: 4**
Total Contact Hours: 75
Total marks: 100

Course Objectives (COs):

1. To teach the fundamental principles of inheritance, including Mendelian genetics, non-Mendelian inheritance patterns, linkage and chromosome mapping
2. To learn the experiments contributing towards the discovery of nucleic acids as genetic materials
3. To familiarize the genome concept and understand the mechanisms of mutation and repair
4. To perform various DNA based experiments

Learning Outcomes (LOs):

1. A graduate would have learnt the principles of inheritance, including Mendelian genetics, non-Mendelian inheritance patterns, linkage, and chromosome mapping
2. Would have understood the importance of the experiments contributing towards the discovery of nucleic acids as genetic materials
3. Would have become familiar with both the genome concept and mechanisms of mutation and repair
4. Will be able to perform experiments on preparation of chromosomes, isolation of DNA and spectrophotometric measurement of Tm

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

Overview of Genetics: Mendel's experiments (monohybrid & dihybrid cross); Mendel's laws of Inheritance; Chromosome theory of inheritance; Laws of probability; Linkage, Crossing over & Recombination.

Unit II:

Nucleic acids as genetic material, experimental evidence (bacterial genetic transformations and Hershey- Chase Experiment): Salient features of viral, prokaryotic and eukaryotic genomes; Repetitive DNA sequences.

Unit III:

Overview of Mutation; Types/kinds of mutation; spontaneous & induced mutation; mutagens; phenotypic effect of mutation; molecular basis of mutation; significance of mutation; mechanism of repair.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Preparation of chromosomes from chironomus larvae/ drosophila salivary gland
2. Isolation of DNA from animal system
3. Spectrophotometric study of DNA
4. Measurement of Tm of DNA sample

Suggested readings:

1. Alberts B, et al. (2022) Molecular Biology of The Cell 7th Edn., WW Norton Pubn.
2. Clark D P, et al. (2019) Molecular Biology 3rd Edn., Elsevier
3. Cox M M & O'Donnell (2011) Molecular Biology- Principle & Practice, W H Freeman
4. Karp et al (2009) Cell & Molecular Biology 6th Edn. Wiley Pbn.
5. Klug W S, Cummings M R, Spencer C A, et al. (2019) Concepts of Genetics 11th Edn., Pearson
6. Krebs J E, et al. (2017) Lewin's Genes XII, Jones and Bartlett Pbn.
7. Pal J K et al (2011) Fundamentals of Molecular Biology. Oxford University Press
8. Pierce B (2019) Genetics: a conceptual approach 7th Edn., W.H.Freeman
9. Watson J D et al (2007) Molecular Biology of the Gene 6th Edn. Benjamin Cummins
10. Weaver et al (2011) Molecular Biology 5th Edn. McGraw Hill

5th Semester

BCH-302	**Intermediary Metabolism-I (Minor)**	**Total Credits: 4** **Total Contact Hours: 75** **Total marks: 100**

Course Objectives (COs):

5. To develop a thorough knowledge among the graduates about metabolism
6. To learn the fate of dietary carbohydrates, proteins and lipids
7. To enable graduates in visualizing energy production and utilization in biological processes
8. To study the interrelationship between carbohydrate, protein and fat metabolism

Learning Outcomes (LOs):

5. Graduates shall be able to understand the concept of anabolism and catabolism of biomolecules and role of high energy compounds in the cell
6. Will understand the interrelations and regulations of the pathways associated with carbohydrates, proteins and lipids metabolism
7. Will be able to isolate glycogen from animal tissues
8. Will be able to assay metabolic enzyme activity

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

Introduction to metabolism (Catabolic, Anabolic & Amphibolic): Carbohydrate metabolism; Glycolysis & its regulation; Warburg effect and Alcoholic fermentations; TCA cycle & its regulation; Gluconeogenesis, Glycogenesis, Glycogenolysis and their regulations; pentose phosphate pathway, Glyoxylate pathway.

Unit II:

Lipid Metabolism: Shuttle of fatty acids into mitochondria, β-oxidation of saturated fatty acids, oxidation of unsaturated and odd chain fatty acids, ATP yield from fatty acid oxidation vis-à-vis Glucose. Biosynthesis of saturated and unsaturated fatty acids. Biosynthesis and regulation of triglycerides and cholesterol.

Unit III:

Amino acid Metabolism: General reactions of amino acid metabolism: transamination, oxidative deamination and decarboxylation. Urea cycle. Biosynthesis of amino acids (Glutamine, tryptophan and Histidine). Degradation of amino acids.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Estimation of urea
2. Isolation and estimation of glycogen from animal tissues
3. Assay of GOT from tissue samples
4. Assay of GPT from tissue samples

Suggested readings:

15. Berg J M, Gatto Jr. G J, Hines J, Tymoczko J L (2023) Biochemistry 10th Edn., W.H.Freeman
16. Davies David D (2011) Intermediary Metabolism in Plants, Cambridge University Press.
17. Devlin T. M. (2010) Textbook of Biochemistry with Clinical correlations 7th Edn., Wiley Pubn.
18. Gareth & Grisham (2008) Biochemistry 4th Edn., Brooks Cole Pbn.
19. Grisham C, Garrett R (2016) Biochemistry 6th Edn., Brooks Cole Pbn.
20. Harper's Illustrated Biochemistry 29th Edn. (2012) , Murray et al. McGraw Hill Pubn.
21. Harris D A (2009) Bioenergetics at a Glance-An Illustrated Introduction, Blackwell Sci. Pub.
22. Nelson D L and Cox M M (2021) Lehninger Principles of Biochemistry 8th Edn., W.H.Freeman
23. Nicholls D G et al (2002) Bioenergetics 3rd Edn., Academic Press.
24. Ochs R S (2022) Biochemistry 2nd Edn., CRC Press
25. Rai A N (1990) handbook of Symbiotic Cyanobacteria, CRC Press
26. Rawn J D (2005) Biochemistry 4th Edn., Prentice Hall
27. Voet D &Voet J G (2004) Biochemistry 3rd Edn., John Wiley & Sons.
28. Zubay G (1999) Biochemistry 4th Edn., W C Brown Commun, Inc.

5th Semester

BCH-303 **Internship** **Total Credits: 4**
Total Contact Hours: 75
Total marks: 100

Course Objective:

- To develop practical laboratory skills essential for biochemical research, including techniques such as protein purification, DNA manipulation, chromatography, spectroscopy, and cell culture.
- To learn how to design and execute experiments independently or as part of a team, including planning, troubleshooting, and adapting protocols as necessary.
- To gain proficiency in analyzing experimental data using statistical methods and bioinformatics tools, and interpreting results within the context of biochemical principles.
- To foster critical thinking skills necessary for evaluating scientific literature, identifying research gaps, and proposing innovative solutions to biochemical problems.
- Communication Skills: To enhance written and oral communication skills by effectively documenting experimental procedures, presenting findings to peers and mentors, and preparing reports or presentations summarizing internship outcomes.

Learning Outcomes:

- Develop practical laboratory skills essential for biochemical research, including techniques such as protein purification, DNA manipulation, chromatography, spectroscopy, and cell culture.
- Learn how to design and execute experiments independently or as part of a team, including planning, troubleshooting, and adapting protocols as necessary.
- Gain proficiency in analyzing experimental data using statistical methods and bioinformatics tools, and interpreting results within the context of biochemical principles.
- Foster critical thinking skills necessary for evaluating scientific literature, identifying research gaps, and proposing innovative solutions to biochemical problems.

S.No	Evaluation of Interns	Marks distribution	Credits
1	Experimental / Field work 12 days x 6 hours = at least for 72 hours	50	2
2	Internship Report 48 hours.	25	1
3	Presentation and Viva.voce	25	1
Total		**100**	**4**

Suggested Readings on Internship:

1. Aniket Singh. (2018). The complete book of internships in India: Intern abroad this summer. Notion Press, Incorporated.
2. Woodard, E. (2015). The ultimate guide to internships: 100 steps to get a great internship and thrive in it. Allworth Press.
3. McLachlan, J. E., & Hess, P. F. (2015). Get an internship and make the most of it: Practical information for high school and community college students. Rowman & Littlefield Publishers.
4. Green, M. E. (1997). Internship success: Real-world, step-by-step advice on getting the most out of internships. VGM Career Horizons.
5. Khoury, R. J., & Selby, J. (2021). How to intern successfully: Insights and actions to optimize your experience. Waterside Productions.
6. Shindell, R. (2019). Total internship management supervisor's handbook: A manager's guide to delivering an amazing internship experience. Intern Bridge, Incorporated.
7. Labor, S. L. (2020). Student internship success workbook (Supervisor's guide): 20+ Lessons and activities for student intern career readiness. Independently published.

6th Semester

BCH-350	**Clinical Biochemistry**	**Total Credits: 4** **Total Contact Hours: 75** **Total marks: 100**

Course Objectives (COs):

1. To allow learning of basic clinical biochemistry and its scope in human health and disease
2. To facilitate understanding of human fluid sample collection, preservation and their clinical analyses including quality control of the lab
3. To make Graduates learn the clinical importance of enzyme investigations and organ/tissue specific tests in disease settings
4. To understand metabolic defects as drivers of clinical metabolic disorders

Learning Outcomes (LOs):

1. Graduates shall be able to understand and appreciate the organization and purpose of a clinical biochemistry laboratory
2. Shall be able to maintain strict quality control for clinical precision and accuracy
3. Will be able to perform biochemical tests in samples

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

Basic concepts of clinical biochemistry; Definition and scope in health and diseases; Organization of clinical laboratory; Automation in clinical biochemistry laboratories; safety; quality control.

Unit II:

Collection and preservation of biological fluids [blood, plasma, serum, urine, cerebral spinal fluid(CSF) and amniotic fluid]: Chemical analysis of blood, urine and CSF. Normal values of important constituents in blood (Plasma/serum), CSF and urine.

Unit III:

Enzymes used in clinical diagnosis; Plasma specific and Non-plasma specific enzymes; Enzyme pattern in health and diseases (lipases, amylases, cholinesterases, alkaline and acid phosphatases, AST, ALT, LDH and CPK); Isoenzymes (LDH & CK) and diagnostic tests; Functional tests of liver and kidney. Inborn errors of metabolism (alkaptonuria, phenylketonuria, albinism). Metabolic disorders (Hypo- and Hyper- glycemia, gout and porphyria).

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Estimation of serum AST & serum ALT activities
2. Estimation of urea in blood
3. Estimation of serum alkaline phosphatase
4. Estimation of bilirubin
5. Estimation of creatinine

Suggested readings:

1. Barrett K E et. al. (2009) Ganong's Review of Medical Physiology 23rd Edn. LANGE Basic Science
2. Baynes J W, et al. (2022) Medical Biochemistry 6th Edn., Elsevier - Health Sciences Pubn.
3. Bhagavan N V et. al. (2011)Essentials of Medical Biochemistry with Clinical cases 1st Edn., Acad.
4. Gupta B (2010) Practical Biochemistry, CBS Publishers
5. Boyer R F (2009) Modern Experimental Biochemistry 3rd Edn. , 5th Impression Pearson edn.
6. Burtis et al (2010) Tietz Fundamentals of Clinical Chemistry 6th Edn. Elsevier
7. Damodaran G K (2011) Practical Biochemistry, Pub Jaypee bros.
8. Farrell et al (2005) Experiments in Biochemistry: A Hands-on Approach 2nd Edn. Brooks Cole Pbn.
9. Ganong W F (2003) Review of Medical Physiology 21st Edn. Appleton & Lange USA
10. Guyton A C & Hall (2010)Textbook of Medical Physiology 12th Edn., W B Saunders.
11. Jayaraman (2011) Laboratory Manual in Biochemistry, New Age Int. Pub.
12. Marshall W J, et al. (2014) Clinical Biochemistry - Metabolic and Clinical Aspects 3rd Edn., Elsevier
13. Murphy M, et al. (2024) Clinical Biochemistry 7th Edn., Elsevier
14. Nigam A & Ayyagiri A (2008) Lab Manual in Biochemistry, Immunology & Biotechnology, Tata
15. Plummer D T (2008 reprint) An Introduction to Practicals in Biochemistry3rd Edn., Tata McGraw- Hill
16. Rao B S & Deshpande (2005) Experimental Biochemistry Graduates Companion I K International Pub
17. Robinson J (2023) Principles and Techniques in Clinical Biochemistry, Springer Med Press Pubn.
18. Russell A (2019) Clinical Biochemistry - Principles and Methods, Medplus Pubn.
19. Sadasivam S and Manickam A (2005) Biochemical Methods,(Rev Edn.) New Age Int. Pub, New Delhi.
20. Santhi D (2010) An Easy Guide for Practical Biochemistry, Jaypee brothers & Medical Publn.
21. Sawhney S K. (2005) Introductory Practical Biochemistry, Alpha Science International Ltd.
22. Wu et al (2006) Tietz Clinical Guide to Laboratory Test 4th edn. Saunders Pbn.

23. Yadav V. K. et al (2012) Biochemistry & Biotechnology- A Lab Manual, Pointer Publns.

6th Semester

BCH-351 **Molecular Biology -II** **Total Credits: 4**
Total Contact Hours: 75
Total marks: 100

Course Objectives (COs):

1. To comprehend the mechanisms of DNA replication
2. To understand the processes of transcription, RNA processing (including splicing, capping, and polyadenylation), and regulation of gene expression at the transcriptional level
3. To comprehend the molecular mechanisms of translation, including ribosome structure, tRNA charging, initiation, elongation, termination, and protein sorting
4. To be proficient in common molecular biology techniques such as PCR (Polymerase Chain Reaction), gel electrophoresis, cloning, DNA sequencing, and genomic analysis methods
5. To explore the diverse applications of recombinant DNA technology
6. To provide graduates with strong practical skills in DNA isolation and amplification

Learning Outcomes (LOs):

1. A graduate would have comprehended the mechanisms of DNA Replication, transcription, translation in both prokaryotes and eukaryotes
2. Would have acquired the practical skills in RNA isolation, separation of nucleic acids and amplifying a DNA sample

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:
DNA replication in prokaryotes (semi conservative, semi-discontinuous & mechanism); inhibitors of DNA replication. Salient differences in comparison with eukaryotes.

Unit II:
Transcription in prokaryotes- Mechanism; inhibitors of transcription; Regulatory RNA (miRNA & snRNA); Catalytic RNA: Salient differences in comparison with eukaryotes. Basic features of the genetic code; Wobble hypothesis; Mechanism of prokaryotic translation; Salient differences in comparison with eukaryotes, signal sequence in protein sorting and targeting.

Unit III:
Regulation of gene expression in prokaryotes; operon concept (*lac* operon and *trp* operon). Molecular cloning: general approach; Application of recombinant DNA technology: PCR, RT-PCR and qPCR.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Agarose gel electrophoresis of DNA
2. Isolation of total RNA and agarose gel electrophoresis
3. Amplification of DNA using PCR

Suggested readings:

1. Alberts B, et al. (2022) Molecular Biology of The Cell 7th Edn., WW Norton Pubn.
2. Clark D P, et al. (2019) Molecular Biology 3rd Edn., Elsevier
3. Cox M M & O'Donnell (2011) Molecular Biology- Principle & Practice, W H Freeman
4. Karp et al (2009) Cell & Molecular Biology 6th Edn. Wiley Pbn.
5. Klug W S, Cummings M R, Spencer C A, et al. (2019) Concepts of Genetics 11th Edn., Pearson
6. Krebs J E, et al. (2017) Lewin's Genes XII, Jones and Bartlett Pbn.
7. Pal J K et al (2011) Fundamentals of Molecular Biology. Oxford University Press
8. Pierce B (2019) Genetics: a conceptual approach 7th Edn.,

   W.H.Freeman Proteomes 2nd Edn., CRC Press
9. Watson J D et al (2007) Molecular Biology of the Gene 6th Edn. Benjamin Cummins
10. Weaver et al (2011) Molecular Biology 5th Edn. McGraw Hill
11. Zlatanova J, van Holde K E (2023) Molecular Biology: Structure and Dynamics of Genomes and

6th Semester

BCH-352	**Biostatistics & Bioinformatics**	**Total Credits: 4** **Total Contact Hours: 75** **Total marks: 100**

Course Objectives (COs):

1. To introduce the basic concepts of Biostatistics and Bioinformatics
2. To learn the methods of statistical analysis in biological systems
3. To introduce biological databases and biological data manipulation using various online resources

Learning Outcomes (Los

1. A graduate will be able to understand and use the basic concepts of Biostatistics
2. Will be able to understand and use the basic concepts of Bioinformatics
3. Will apply the methods of statistical analysis in biological systems
4. Will be able to use biological databases and basic data biological data manipulation using online resources

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

Collection of data, Primary and Secondary data, classification and tabulation of data Measures of central tendency; Measures of dispersion, Methods of sampling- sampling theory & test of significance (definition of random sampling, simple random sampling, systematic & stratified sampling and confidence level for those sample statistics).

Unit II:

Correlation coefficient, Regression analysis; Probability (theorem on total probability of two events, definition of conditional probability with some elementary problems), Distribution-definition properties and uses of Bernoulli trials, Binomial, Poisson & Normal distribution.

Definition and applications of x2, t, F & Z statistic: definition of confidence level & limits.

Unit III:

Introduction to Bioinformatics (concept and application); Genomics, nucleotide sequence database; DNA data bank (NCBI GenBank). Proteomics: protein sequence database (PDB): Introduction on cheminformatics.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Draw a histogram, pie diagram and frequency polygon for the given data using MS Excel
2. Calculate measures of central tendency and dispersion for the given data using MS Excel
3. Calculate the Karl Pearson's correlation coefficient for the given set of data using MS Excel
4. Study of NCBI database
5. Analysis of protein sequence from protein database
6. Analysis of DNA sequence from DNA database
7. Analysis of proteins from PDB

Suggested readings:

1. Bosu O, Thukral S K (2006) Bioinformatics: Databases, Tools, Algorithms, Oxford University Press
2. Daniel W W, Cross C L (2014) Biostatistics: Basic Concepts and Methodology for the Health Sciences 10th Edn., Wiley Pubn.
3. Freedman D (1998) Statistics 3rd Edn. W W Norton & Co. Pbn
4. Goswami R (2022) Biostatistics and Computer Applications, Prints Publications Pvt. Ltd.
5. Hayen A (2023) Biostatistics - Principles and Practice, American Academic Publisher
6. Ismail H D (2022) Bioinformatics: A Practical Guide to NCBI Databases and Sequence Alignments, Taylor & Francis/CRC Press
7. Johns E (2023) Fundamentals of Biostatistics, White Press Academic
8. Singh R (2015) Bioinformatics: Genomics and proteomics 1st Edn. Vikas Publishing House Pvt Ltd
9. Singh R (2015) Bioinformatics: Genomics and proteomics 1stEdn. Vikas Publishing House Pvt Ltd
10. Yates D S (2010) The Practice of Statistics 3rd Edn. W H Freeman
11. Zar J H Biostatistical Analysis 5th Edn.

6th Semester

BCH-353 **Intermediary Metabolism-II** **Total Credits: 4**
Total Contact Hours: 75
Total marks: 100

Course Objectives (COs):

1. To learn about the fundamental concepts and mechanism of nucleotide metabolism
2. To know the differences between *de novo* and salvage pathways of nucleotide biosynthesis
3. To interpret the degradation of purine and pyrimidine biosynthesis
4. To learn about the concept and mechanism of respiratory electron transport chain, oxidative phosphorylation and ATP synthesis
5. To explain the carbon assimilation pathways and photosystems in plants
6. To understand the photosystems in purple and green sulfur bacteria

Learning Outcomes (LOs):

1. Graduates will be able to evaluate the biosynthesis and degradation of purines and pyrimidines
2. Will learn basic concepts of bioenergetics, mechanism of oxidative phosphorylation and photophosphorylation
3. Will be able to explain the chemiosmotic hypothesis of ATP synthesis
4. Will be able to understand the metabolic pathways of photosynthesis
5. Will be able to differentiate between photosystem of purple and green sulfur bacteria
6. Will be able to perform assays on plant-based enzymes and pigments

(Theory)

Total Credits: 3
Total Contact Hours: 45

Unit I:

Nucleotide Metabolism: Sources of the atoms in the purine and pyrimidine molecules. Biosynthesis and regulation of purines and pyrimidines (***de novo*** & ***salvage pathways***). Degradation of purine and pyrimidine biosynthesis.

Unit II:

Introduction to bioenergetics: Chemiosmotic Theory, Respiratory electron transfer chain. Mechanism of ATP production, Binding change mechanism, inhibitors of electron transport chain and uncouplers of oxidative phosphorylation, Regulation of oxidative phosphorylation, Stoichiometry of oxidative phosphorylation.

Unit III:

Carbon assimilation pathways in plants; Photophosphorylation; Photochemical reaction centre,

PSI, PSII, Water splitting complex, Accessory pigments, ATP synthase, Stoichiometry of photophosphorylation. Photosystem in purple and green sulfur bacteria.

(Practical)

Total Credits: 1
Total Contact Hours: 30

Unit IV:

1. Study on the activity of inorganic pyrophosphatase
2. Study on the activity of acid phosphatase
3. Isolation and estimation of photosynthetic pigments

Suggested readings:

1. Berg J M, Gatto Jr. G J, Hines J, Tymoczko J L (2023) Biochemistry 10th Edn., W.H.Freeman
2. Davies David D (2011) Intermediary Metabolism in Plants, Cambridge University Press.
3. Devlin T. M. (2010) Textbook of Biochemistry with Clinical correlations 7th Edn., Wiley Pubn.
4. Gareth & Grisham (2008) Biochemistry 4th Edn., Brooks Cole Pbn.
5. Grisham C, Garrett R (2016) Biochemistry 6th Edn., Brooks Cole Pbn.
6. Harper's Illustrated Biochemistry 29th Edn. (2012) , Murray et al. McGraw Hill Pubn.
7. Harris D A (2009) Bioenergetics at a Glance-An Illustrated Introduction, Blackwell Sci. Pub.
8. Nelson D L and Cox M M (2021) Lehninger Principles of Biochemistry 8th Edn., W.H.Freeman
9. Nicholls D G et al (2002) Bioenergetics 3rd Edn., Academic Press.
10. Ochs R S (2022) Biochemistry 2nd Edn., CRC Press
11. Rai A N (1990) handbook of Symbiotic Cyanobacteria, CRC Press
12. Rawn J D (2005) Biochemistry 4th Edn., Prentice Hall
13. Voet D &Voet J G (2004) Biochemistry 3rd Edn., John Wiley & Sons.
14. Zubay G (1999) Biochemistry 4th Edn., W C Brown Commun, Inc.

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