GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Biotechnology
Subject Code: BE04004011
Subject Name: Biochemistry

w. e. f. Academic Year:	2024-2025
Semester:	4
Category of the Course:	Professional Core Course

Prerequisite:	Biology for Engineers
Rationale:	Biochemistry explains life at the molecular level by studying the structure and function of biomolecules like proteins, DNA, and enzymes. It provides the foundation for understanding diseases, developing drugs, and creating diagnostic tools. This field is essential for advances in medicine, nutrition, agriculture, and biotechnology. By revealing how chemical processes drive biological functions, biochemistry connects basic science to real-world health and environmental solutions.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Identify the structure and functions of biomolecules	15
CO-2	Understand complex biochemical pathways and metabolism	15
CO-3	Interpret biochemical reactions of proteins, carbohydrates and nucleic acids with organic and inorganic solvents	25
CO-4	Estimate and separate biomolecules using chromatography and electrophoresis	25
CO-5	Determine the kinetic parameters of enzymatic reactions	20

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/ CA (I)	PBL (I)	ESE (V)	
45	0	30	45	120	4	70	30	20	30	50	200

- **Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.**

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Fundamental facts of life. Importance of water as the medium of biological systems. Concepts of pH, acids, bases, and buffer systems in biological environments. Nature of weak and covalent bonds in biomolecules. Introduction to bioenergetics: laws of thermodynamics in biological systems, energy transformations, and biological oxidation-reduction reactions.	10
2	**Molecules of Life:** Amino Acids and Peptides: Classification, structure, and chemical properties of amino acids. Peptide bond formation and the structure of peptides.Proteins: Structural hierarchy of proteins—primary, secondary, tertiary, and quaternary structures. Structural motifs and domains, folding, stability, and functional significance. Denaturation, renaturation, and protein misfolding diseases (e.g., prion diseases, amyloidoses). Nucleic Acids: DNA structure, types of DNA secondary structures (A-DNA, B-DNA, Z-DNA), and principle classes of RNA (mRNA, tRNA, rRNA, small RNAs). DNA supercoiling and chromatin organization. Carbohydrates: Structure and biological functions of monosaccharides, disaccharides, polysaccharides, glycoproteins, and proteoglycans.Lipids: Structures and functions of fats, oils, phospholipids, glycolipids, steroids, and membrane lipids. Lipid bilayers and membrane structure. Vitamins: Introduction to vitamins, classification (water-soluble and fat-soluble), biochemical functions, and diseases related to vitamin deficiencies.	15
3	**Metabolism:** Overview of metabolic pathways and metabolic integration. Carbohydrate metabolism: glycolysis, gluconeogenesis, pentose phosphate pathway, glycogen metabolism. Citric acid cycle and its central role in metabolism. Amino acid catabolism and nitrogen metabolism. Lipid metabolism: β-oxidation of fatty acids, biosynthesis of fatty acids, ketone bodies. Oxidative phosphorylation and photophosphorylation: mechanisms of ATP synthesis, electron transport chain. Nucleotide metabolism: DNA and RNA synthesis and degradation. Protein metabolism: proteolysis, ubiquitin-proteasome system. Introduction to metabolic regulation and hormonal control (insulin, glucagon, epinephrine). Basics of signal transduction pathways (cAMP, IP3-DAG pathways). Analytical techniques in biochemistry: spectrophotometry, chromatography, electrophoresis, mass spectrometry, and techniques for quantification of small and macromolecules.	10

4	**Enzymes and Enzyme Kinetics:** Nature of enzymes as biological catalysts. Classification of enzymes based on EC system with examples. Enzyme-catalyzed reaction mechanisms. Michaelis–Menten kinetics and derivation of kinetic equations. Advanced enzyme kinetics: Lineweaver-Burk plot, Eadie-Hofstee plot. Mechanisms of enzyme action and transition state theory. Enzyme inhibition: competitive, non-competitive, uncompetitive, and mixed inhibition. Regulatory enzymes: allosteric regulation, covalent modification (phosphorylation), feedback inhibition. Introduction to coenzymes and cofactors (e.g., NAD+, FAD, biotin, coenzyme A). Enzyme engineering and industrial applications of enzymes.	**10**
	TOTAL	**45**

Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**20**	**20**	**20**	**10**	**10**

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Reference Books:

1. David L. Nelson, Michael M. Cox, Lehninger Principles of Biochemistry, W. H. Freeman and Company, 2017, 7th Edition
2. Reginald H. Garrett, Charles M. Grisham, Biochemistry, Cengage Learning, 2017, 6th Edition
3. Keith Wilson and John Walker, Practical Biochemistry: Principles and Techniques, Cambridge University Press, 2000, 5th Edition
4. Victor Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly and P. Anthony Weil, Harpers Illustrated Biochemistry, Tata McGraw – Hill, 2015, 30th Edition
5. Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto, Jr., and Lubert Stryer, Biochemistry, Macmillan, 2015, 8th Edition

List of Experiments / Practical Demonstrations

1. Qualitative analysis of Carbohydrates, amino acids & proteins.
2. Quantitative estimation of protein by Biuret method & Lowry method.
3. Quantitative estimation of reducing sugars by DNS method.
4. Quantitative estimation of total sugars by Anthrone method.
5. Quantitative estimation of DNA by Diphenylamine method.
6. Quantitative estimation of RNA by Orcinol method.
7. Determination of Absorption Maxima (λmax).

8. Estimation of Nucleic acids & Protein purity by spectrometric analysis.
9. Quantitative estimation of protein and nucleic acids concentration by UV-absorption method.
10. Effect of substrate concentration and determination of Michaelis–Menten parameters Vmax & Km. Separation of amino acids by Thin layer chromatography, Determination of molecular weight of a protein by SDS-PAGE.

Major Equipment

1. UV-Vis Spectrophotometer – for quantitative analysis of biomolecules
2. Centrifuge (refrigerated) – for separating cellular components and macromolecules
3. pH Meter – for buffer preparation and enzyme activity studies
4. Electrophoresis Unit (SDS-PAGE) – for protein separation and analysis
5. Micropipettes and Vortex Mixer – for accurate sample handling and mixing

Open-Source Software / Learning Websites

1. PyMOL – molecular visualization of proteins and nucleic acids
2. UCSF Chimera – 3D structure analysis and modeling
3. Expasy Tools (ProtParam, Compute pI/Mw) – protein property prediction
4. KEGG & BRENDA – pathway and enzyme databases
5. ChemCollective Virtual Lab – interactive biochemistry simulations

List of suggested activities for Problem Based Learning:

1. Perform enzyme kinetics assay (e.g., amylase) and plot Michaelis-Menten curve
2. Separate amino acids using paper chromatography and calculate Rf values
3. Estimate protein concentration in unknown samples using Biuret method
4. Analyze a 3D protein structure (PDB) using PyMOL or Chimera
5. Create a scientific poster on a metabolic pathway (e.g., glycolysis or TCA cycle)

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