# Syllabus of 3-Year Degree/4-Year Honours in Biohemistry

## Based on National Curriculum and Credit Framework for Undergraduate Programme With effect from 2023-24

**Kazi Nazrul University**

**Asansol, WestBengal**

## Semester- I

## Major Paper

# Course Name: Molecules of Life

### Course Code: BSCBCMMJ101

| Course Type: MAJOR(MJC) | Course Details: **MJC-1** | | | L-T-P: **3-0-4** | |
|---|---|---|---|---|---|
| Credit: 5 | Full Marks: 100 | CA Marks | | ESE Marks | |
| | | Practical | Theoretical | Practical | Theoretical |
| | | 30 | 15 | 20 | 35 |

**MOLECULES OF LIFE (THEORY)**

**CREDIT: 3 (Marks 50)**

***Course Learning Outcomes:***

- Exposure with the nature of various biomolecules present in living cells.
- Get exposed to key contributions of scientists such as Hans Kreb, G. N. Ramachandran, Melvin Calvin, Louis Pasteur, HarGobind Khorana, Watson and Crick and Venky Ramakrishnan, etc. in order to create scientific interest amongst students in life processes.
- To understand the properties of carbohydrates, proteins, lipids, cholesterol, DNA, RNA, glycoproteins and glycolipids and their importance in biological systems.
- To understand the process of fermentation and manufacture of Biodiesel.
- To develop skills to determine amino acid and nucleotide sequences of proteins and DNA respectively.

Students will be exposed to the history of Biochemistry and key contributions of scientists such as Hans Kreb, G. N. Ramachandran, Melvin Calvin, Louis Pasteur, Har Gobind Khorana, Watson and Crick and Venky Ramakrishnan. They will study the properties of carbohydrates, proteins, lipids, cholesterol, DNA, RNA, glycoproteins and glycolipids and their importance in biological systems. They will understand the process of fermentation and manufacture of Biodiesel. They will understand the methods of determination of amino acid and nucleotide sequence of proteins and DNA respectively.

***Course Content:***

**The foundations of biochemistry**

Cellular and chemical foundations of life

**Water**

Unique properties, weak interactions in aqueous systems, ionization of water, buffers, water as a reactant and fitness of the aqueous environment.

**Carbohydrates and glycobiology**

Monosaccharides - structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, Concept of asymmetry; Stereoisomerism; Conformations and configurations; Flying-wedge, Fischer, Sawhorse and Newman projection formulae and their interconversions; nomemclature D/L, R/S, E/Z, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives, oxidation of sugars. Formation of disaccharides, reducing and nonreducing disaccharides. Polysaccharides – homo- and heteropolysaccharides, structural and storage polysaccharides. Structure and role of proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides). Carbohydrates as informational molecules, working with carbohydrates

**Lipids**

Building blocks of lipids - fatty acids, glycerol, ceramide. Storage lipids - triacyl glycerol and waxes Structural lipids in membranes – glycerophospholipids, galactolipids and sulpholipids, sphingolipids and sterols, structure, distribution and role of membrane lipids. Plant steroids. Lipids as signals, cofactors and pigments

**Amino acids**

Structure and classification, physical, chemical and optical properties of amino acids, essential amino acids and non-essential amino acids.

**Nucleic acids**

Nucleotides - structure and properties. Nucleic acid structure – Watson-Crick model of DNA. Structure of major species of RNA - mRNA, tRNA and rRNA. Nucleic acid chemistry - UV absorption, effect of acid and alkali on DNA. Other functions of nucleotides - source of energy, component of coenzymes, second messengers.

**Vitamins**

Structure and active forms of water soluble and fat soluble vitamins, deficiency diseases and symptoms, hypervitaminosis

**MOLECULES OF LIFE (PRACTICALS)**

**CREDIT: 2 (Marks 50)**

***Course Learning Outcomes:***

- Exposure to basic reactions of biomolecules.
- Determine presence of biomolecules like carbohydrates, proteins, lipids, etc. in known and unknown samples.
- Determine the extent of adulteration in samples containing biomolecules.

The student will gain awareness about basic reactions of biomolecules and their utility in identification of adulterants.

***Course Content:***

1. Safety measures in laboratories.
2. Preparation of buffers.
3. Determination of pKa of acetic acid and glycine (pH metric titration).
4. Qualitative tests for carbohydrates, lipids, amino acids, proteins and nucleic acids.
5. Separation of amino acids/ sugars/ bases by thin layer chromatography.

***References/ Suggested Readings***

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13: 978-1-4641-0962-1 /ISBN:10:1-4292-3414-8
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN:978-0-470-28173-4.

## Semester- II

## Major Paper

# Course Name: Cell Biology

### Course Code: BSCBCMMJ201

| Course Type: MAJOR(MJC) | Course Details: **MJC-2** | | | L-T-P: **3-0-4** | |
|---|---|---|---|---|---|
| Credit: 5 | Full Marks: 100 | CA Marks | | ESE Marks | |
| | | Practical | Theoretical | Practical | Theoretical |
| | | 30 | 15 | 20 | 35 |

**CELL BIOLOGY (THEORY)**

**CREDIT: 3 (Marks 50)**

***Course Learning Outcomes:***

- Understanding of the structure of cell and various cellular events.
- Understanding of the function of various subcellular organelles.
- Students will learn about cell theory and techniques for fractionation of sub-cellular organelles.

- They will be acquainted to various microscopic techniques to visualize subcellular organelles.
- Students will have an understanding of the composition of cytoskeleton and extracellular matrix.
- Students will acquire knowledge of cell cycle, cell division and cell death mechanisms.

This course will provide an understanding of the structure of cell and function of various subcellular organelles. Students will learn about cell theory, basic cell structure, cell fractionation and cell visualization techniques. Besides, students will have an understanding of the composition of cytoskeleton and extracellular matrix. Students will acquire knowledge of cell cycle, cell division and cell death mechanisms.

***Course Content:***

**Introduction to cell biology**

Prokaryotic (archaea and bacteria) and eukaryotic cell (animal and plant cells), cells as experimental models.

**Tools of cell biology**

Light microscopy, phase contrast microscopy, fluorescence microscopy, confocal microscopy, electron microscopy, FACS. Centrifugation for subcellular fractionation.

**Structure of cell membrane and different cell organelles**

Cell membrane –Peripheral and integral membrane protein, unit membrane model and Singer & Nicolson model.

Structure of nuclear envelope, nuclear pore complex. ER structure. Organization of Golgi. Lysosome.

Structure and functions of mitochondria, chloroplasts and peroxisomes.

**Cytoskeletal proteins**

Structure and organization of actin filaments. Treadmilling and role of ATP in microfilament polymerization, organization of actin filaments. Non-muscle myosin. Intermediate filament proteins, assembly and intracellular organization. Assembly, organization and movement of cilia and flagella.

**Protein trafficking**

Selective transport of proteins to and from the nucleus. Regulation of nuclear protein import and export. Targeting proteins to ER, smooth ER and lipid synthesis. Export of proteins and lipids from ER and into ER. Lipid and polysaccharide metabolism in Golgi. Protein sorting and export from Golgi. Mechanism of vesicular transport, cargo selection, coat proteins and vesicle budding, vesicle fusion. Protein import and mitochondrial assembly, protein export from mitochondrial matrix. Import and sorting of chloroplast proteins.

**Cell wall and extracellular matrix**

Prokaryotic and eukaryotic cell wall, cell matrix proteins. Cell-matrix interactions and cellcell interactions. Adherence junctions, tight junctions, gap junctions, desmosomes, hemidesmosomes, focal adhesions and plasmodesmata.

**Cell cycle, cell death and cell renewal**

Eukaryotic cell cycle, restriction point, and checkpoints. Cell division. Apoptosis and necrosis - brief outline. Salient features of a transformed cell.

**CELL BIOLOGY (PRACTICAL)**

**CREDITS: 2 (Marks 50)**

***Course Learning Outcomes:***

- Students will learn the handling of microscope.
- Obtain hands-on training in basic separation techniques in biochemistry
- Gain expertise in the isolation of various cell organelles and staining of cellular biomolecules.

Students will learn thehandling of microscope. They will gain knowledge about the structure and function of various cell organelles. The students will obtain hands-on training in basic separation techniques in biochemistryand gain expertise in the isolation of various cell organelles and staining of cellular biomolecules.

***Course Content:***

1. Visualization of animal and plant cell by methylene blue.
2. Identification of different stages of mitosis in onion root tip.
3. Identification of different stages of meiosis in grasshopper testis / onion flower bud.
4. Visualization of nuclear fraction by acetocarmine stain.

***References/ Suggested Readings:***

1. The Cell: A Molecular Approach (2009) 5th ed., Cooper, G.M. and Hausman, R.E., ASM Press & Sunderland (Washington DC), Sinauer Associates, MA, ISBN:978-0-87893-300-6.

2. Molecular Cell Biology (2012) 7th ed., Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell. J., W.H. Freeman & Company (New York), ISBN:13:978-1-4641-0981-2 / ISBN:10: 1-4641-0981-8.

3. Molecular Biology of the Cell (2008) 5th ed., Alberts, B., Johnson,A., Lewis, J., and Enlarge, M.,Garland Science (Princeton), ISBN:0-8153-1619-4 / ISBN:0-8153-1620-8.

## Semester- I

## Minor Paper

# Course Name: Molecules of Life

### Course Code: BSCBCMMN101

| Course Type: MINOR(MNC) | Course Details: **MNC-1** | | | L-T-P: **3-0-4** | |
|---|---|---|---|---|---|
| | Full Marks: | CA Marks | | ESE Marks | |
| | | Practical | Theoretical | Practical | Theoretical |

| | | | | | |
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**MOLECULES OF LIFE (THEORY)**

**CREDIT: 3 (Marks 50)**

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- Get exposed to key contributions of scientists such as Hans Kreb, G. N. Ramachandran, Melvin Calvin, Louis Pasteur, HarGobind Khorana, Watson and Crick and Venky Ramakrishnan, etc. in order to create scientific interest amongst students in life processes.
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- To understand the process of fermentation and manufacture of Biodiesel.
- To develop skills to determine amino acid and nucleotide sequences of proteins and DNA respectively.

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***Course Content:***

**The foundations of biochemistry**

Cellular and chemical foundations of life

**Water**

Unique properties, weak interactions in aqueous systems, ionization of water, buffers, water as a reactant and fitness of the aqueous environment.

**Carbohydrates and glycobiology**

Monosaccharides - structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, Concept of asymmetry; Stereoisomerism; Conformations and configurations; Flying-wedge, Fischer, Sawhorse and Newman projection formulae and their interconversions; nomemclature D/L, R/S, E/Z, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives, oxidation of sugars. Formation of disaccharides, reducing and nonreducing disaccharides. Polysaccharides – homo- and heteropolysaccharides, structural and storage polysaccharides. Structure and role of proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides). Carbohydrates as informational molecules, working with carbohydrates

**Lipids**

Building blocks of lipids - fatty acids, glycerol, ceramide. Storage lipids - triacyl glycerol and waxes Structural lipids in membranes – glycerophospholipids, galactolipids and sulpholipids, sphingolipids and sterols, structure, distribution and role of membrane lipids. Plant steroids. Lipids as signals, cofactors and pigments

**Amino acids**

Structure and classification, physical, chemical and optical properties of amino acids, essential amino acids and non-essential amino acids.

**Nucleic acids**

Nucleotides - structure and properties. Nucleic acid structure – Watson-Crick model of DNA. Structure of major species of RNA - mRNA, tRNA and rRNA. Nucleic acid chemistry - UV absorption, effect of acid and alkali on DNA. Other functions of nucleotides - source of energy, component of coenzymes, second messengers.

**Vitamins**

Structure and active forms of water soluble and fat soluble vitamins, deficiency diseases and symptoms, hypervitaminosis

**MOLECULES OF LIFE (PRACTICALS)**

**CREDIT: 2 (Marks 50)**

***Course Learning Outcomes:***

- Exposure to basic reactions of biomolecules.
- Determine presence of biomolecules like carbohydrates, proteins, lipids, etc. in known and unknown samples.
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***Course Content:***

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## Semester- II

## Minor Paper

# Course Name: Cell Biology

### Course Code: BSCBCMMN201

| Course Type: MINOR(MNC) | Course Details: **MNC-2** | | L-T-P: **3-0-4** | |
|---|---|---|---|---|
| Credit: 5 | Full Marks: 100 | CA Marks | | ESE Marks | |
| | | Practical | Theoretical | Practical | Theoretical |
| | | 30 | 15 | 20 | 35 |

**CELL BIOLOGY (THEORY)**

**CREDIT: 3 (Marks 50)**

***Course Learning Outcomes:***

- Understanding of the structure of cell and various cellular events.
- Understanding of the function of various subcellular organelles.
- Students will learn about cell theory and techniques for fractionation of sub-cellular organelles.
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***Course Content:***

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Cell membrane –Peripheral and integral membrane protein, unit membrane model and Singer & Nicolson model.

Structure of nuclear envelope, nuclear pore complex. ER structure. Organization of Golgi. Lysosome.

Structure and functions of mitochondria, chloroplasts and peroxisomes.

**Protein trafficking**

Selective transport of proteins to and from the nucleus. Regulation of nuclear protein import and export. Targeting proteins to ER, smooth ER and lipid synthesis. Export of proteins and lipids from ER and into ER. Lipid and polysaccharide metabolism in Golgi. Protein sorting and export from Golgi. Mechanism of vesicular transport, cargo selection, coat proteins and vesicle budding, vesicle fusion. Protein import and mitochondrial assembly, protein export from mitochondrial matrix. Import and sorting of chloroplast proteins.

**Cytoskeletal proteins**

Structure and organization of actin filaments. Treadmilling and role of ATP in microfilament polymerization, organization of actin filaments. Non-muscle myosin. Intermediate filament proteins, assembly and intracellular organization. Assembly, organization and movement of cilia and flagella.

**Cell wall and extracellular matrix**

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**Cell cycle, cell death and cell renewal**

Eukaryotic cell cycle, restriction point, and checkpoints. Cell division. Apoptosis and necrosis - brief outline. Salient features of a transformed cell.

**CELL BIOLOGY (PRACTICAL)**

**CREDITS: 2 (Marks 50)**

***Course Learning Outcomes:***

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***Course Content:***

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3. Molecular Biology of the Cell (2008) 5th ed., Alberts, B., Johnson,A., Lewis, J., and Enlarge, M.,Garland Science (Princeton), ISBN:0-8153-1619-4 / ISBN:0-8153-1620-8.

## Semester- I

## SEC

# Course Name: TOOLS AND TECHNIQUES IN BIOCHEMISTRY

**Course Code: BSCBCMSE101**

<table>
<tr><td>Course Type:SEC</td><td colspan="2">Course Details:SEC-1</td><td>L-T-P: 0-0-6</td></tr>
<tr><td rowspan="3">Credit:2</td><td rowspan="3">Full Marks: 50</td><td>CA Marks</td><td>ESE Marks</td></tr>
<tr><td>Practical</td><td>Practical</td></tr>
<tr><td>30</td><td>20</td></tr>
</table>

**TOOLS AND TECHNIQUES IN BIOCHEMISTRY(PRACTICALS)**

**CREDIT: 2 (Marks 50)**

***Course Learning Outcomes:***

1. Understanding Good laboratory practices in a chemistry/biochemistry laboratory.
2. Learn safety and precautionary measures for working in alaboratory.
3. Develop skill and proficiency in preparation of laboratory reagents.
4. Use of handling of glass wares, minor equipment for conducting experiments.
5. Develop skills to prepare standard chemical solutions and secondary standards.
6. Demonstration of basic oxidation and reduction reactions.

***Content/ Syllabus: Unit wise course content distribution:***

**Unit 1 Biochemical reagents and solutions**

Safety practices in the laboratory. Preparation and storage of solutions. Concepts of solution concentration and storing solutions. Quantitative transfer of liquids. Concept of a buffer, Henderson-Hassel Bach equation, working of a pH meter.

**Exercise**

Preparation of a buffer of given pH and molarity.

**Unit 2 Spectrophotometric techniques**

Principle and instrumentation of UV-visible and fluorescence spectroscopy.

**Exercises**

Determination of the absorption maxima and molar extinction coefficient (of a relevant organic molecule).
Measurement of fluorescence spectrum.
Determination of concentration of a protein solution by Lowry method.

**Unit 3 Introduction and importance of virtual labs in biochemistry.**

Protein and Nucleic acid databases.
Exercise: Retrieval of Protein and Nucleic acid sequence from different online data base.

***References/ Suggested Readings:***

1. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN:978-0-470-85602-4 / ISBN:978-0-470-85603-1.

2. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder, D.,W.H. Freeman and Company (New York), ISBN:0-7167-1315-2/ISBN:0-7167-1444-2.

3.An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN:13: 978-0-07-099487-4 / ISBN:10:0-07-099487-0.

## Semester- II

## SEC

# Course Name: PROTEIN PURIFICATION TECHNIQUES

### Course Code: BSCBCMSE201

| Course Type: SEC | Course Details: SEC-2 | | L-T-P: 0-0-6 |
|---|---|---|---|
| Credit: 2 | Full Marks: 50 | CA Marks | ESE Marks |
| | | Practical | Practical |
| | | 30 | 20 |

### *Course Learning Outcomes:*

On successful completion of this course, students will be able to:

1. Demonstrate sound knowledge of current protein purification techniques used in biomedical research and the biotechnology industry
2. Demonstratepracticallaboratoryskillsinchromatographyandproteinpurification.
3. Documentlaboratoryproceduresanddataeffectivelyinanelectronicnotebook.
4. Interpretandcriticallyanalyzeexperimentaldatarelatingtoproteinpurification.
5. Effectively communicate results and conclusions to a broad audience.

### *Content/ Syllabus: Unit wise course content distribution:*

**Unit 1 Purification and characterization of a protein from a complex mixture (native or heterologously expressed) involving the following methods/techniques**

**Exercises**

Preparation of the sample.
Ion-exchange chromatography.
Gel filtration chromatography.
Affinity chromatography.
Electrophoresis.

**Unit 2 Demonstration of High Performance Liquid Chromatography (HPLC)**

### *References/ Suggested Readings:*

1. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D.,Wiley Blackwell (West Sussex), ISBN:978-0-470-85602-4 /ISBN:978-0-470-85603-1.

2. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder, D., W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.

3. An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGrawHill Education Pvt. Ltd. (New Delhi), ISBN:13: 978-0-07-099487-4 / ISBN:10: 0-07- 099487-0.

**Semester- III**

**Major Paper**

**Course Name: Biochemistry of Proteins**
**Course Code: BSCBCMMJ301**

| **Course Type: MAJOR(MJC)** | **Course Details: MJC-3** | | **L-T-P: 3-0-4** | |
|---|---|---|---|---|
| **Credit: 5** | **Full Marks: 100** | **CA Marks** | | **ESE Marks** | |
| | | **Practical** | **Theoretical** | **Practical** | **Theoretical** |
| | | **30** | **15** | **20** | **35** |

Course Learning Outcomes After completion of the course, a student will learn

***Learning Objectives:***

- Understand the diverse functions of proteins in a cell

- Understand the hierarchy of protein architecture – primary, secondary, tertiary & quaternary structure, with the ability to distinguish features of globular & fibrous proteins

- Be able to comprehend the fundamental mechanisms of protein folding and stability and their relation to conformational diseases

- Be able to describe and discuss the separation and purification techniques used in protein chemistry • Learn to access and use the databases related to protein sequence and structure

- Understand specialized proteins like membrane proteins, defense proteins and motor proteins

- Gain comprehension of structure-function relationship of proteins and their significance in physiology, diseases and applications in industry and medicine.

## *Content/ Syllabus: Unit wise course content distribution*

**Unit -1:Introduction to amino acids, peptides and proteins**

Amino acids and their properties - hydrophobic, polar and charged. Biologically important peptides - hormones, antibiotics and growth factors. Multimeric proteins, conjugated proteins and metallo proteins. Diversity of function

**Unit-2: Extraction of proteins for downstream processing**

Solubilization of proteins from their cellular and extracellular locations. Use of simple grinding methods, homogenization, ultrasonication, French press and centrifugation.

**Unit -3: Separation technique**

Ammonium sulphate fractionation, solvent fractionation, dialysis and lyophilization. Ionexchange chromatography, molecular sieve chromatography, hydrophobic interaction/reverse phase chromatography, affinity chromatography, HPLC and FPLC

**Unit -4: Characterization of proteins**

Determination of purity, molecular weight, extinction coefficient and sedimentation coefficient, IEF,SDSPAGE and 2-D electrophoresis.

**Unit -5: Covalent structure of proteins**

Organization of protein structure into primary, secondary, tertiary and quaternary structures. N-terminal and C-terminal amino acid analysis. Sequencing techniques - Edman degradation. Generation of overlap peptides using different enzymes and chemical reagents. Disulfide bonds and their location. Mass spectrometric analysis, tandem MS. Solid phase peptide synthesis

**Unit -6: Three dimensional structures of proteins**

Nature of stabilizing bonds - covalent and non covalent. Importance of primary structure in folding. The peptide bond - bond lengths and configuration. Dihedral angles psi and phi. Helices, sheets and turns. Ramachandran map. Techniques used in studying 3-D structures -X-ray diffraction and NMR. Motifs and domains. Tertiary and quaternary structures. Structures of myoglobin and haemoglobin

**Unit -7: Protein folding and conformational diseases**

Denaturation and renaturation of Ribonuclease A. Introduction to thermodynamics of folding and molten globule. Assisted folding by molecular chaperones, chaperonins and PDI. Defects in protein folding. Diseases –Alzheimer's and Prion based.

**Unit- 8: Introduction to protein structure database**

Protein sequence and structure databases (PDB). Use of sequence and domain information. Viewing protein structures using in silico tools.

**Unit -9: Myoglobin and haemoglobin**

Oxygen binding curves, influence of 2,3-BPG, CO2 and Cl-. Hill plot. Cooperativity between subunits and models to explain the phenomena - concerted and sequential models. Haemoglobin disorders.

**Unit- 10: Specialized proteins** - antibodies and actin-myosin motors

Antibody structure and binding to antigens. ATP activated actin - myosin contractions.

**Unit – 11: Membrane proteins**

Integral and membrane associated proteins. Hydropathy plots to predict transmembrane domains. Significance of membrane proteins - bacteriorhodopsin.

**PRACTICAL : Marks 50**

1.Estimation of proteins using UV absorbance and Biuret method.

2.Microassay of proteins using Lowry/Bradford method.

3.Isoelectric pH of casein.

4.Ammonium sulphate fractionation of serum proteins.

5.Separation of albumin from serum using anion-exchange chromatography.

6. SDS-PAGE analysis of proteins.

## *References/ Suggested Readings*

1.Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H.Freeman and Company (New York), ISBN:13: 978-1-4641-0962-1 / ISBN:10:1-4292-3414-8.

2.Physical Biochemistry (2009) 2nd ed., Sheehan, D., Wiley-Blackwell (West Sussex), ISBN: 9780470856024 / ISBN: 9780470856031.

3.The Tools of Biochemistry (1977; Reprint 2011) Cooper, T.G., Wiley India Pvt. Ltd. (New Delhi), ISBN: 978-81-265-3016-8.

4. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New Jersey),ISBN:978-0-470-28173-4.

5. Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5,ISBN:13:978-1-4292-2936-4.

**Semester- III**

**Major Paper**

**Course Name: Enzymes**
**Course Code: BSCBCMMJ302**

<table>
<tr><td>Course Type: MAJOR(MJC)</td><td colspan="3">Course Details: MJC-4</td><td colspan="2">L-T-P: 3-0-4</td></tr>
<tr><td rowspan="3">Credit: 5</td><td rowspan="3">Full Marks: 100</td><td colspan="2">CA Marks</td><td colspan="2">ESE Marks</td></tr>
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</table>

Course Learning Outcomes After completion of the course, a student will learn

### *Learning Objectives:*

- Students will learn the nature and importance of enzymes in living systems

- Students will gain insight into the thermodynamic and molecular basis of catalysis by enzymes and the underlying basis of their specificity

- Students will understand the mechanisms of enzyme action, kinetics of enzyme catalyzed reactions and clinical importance of enzyme inhibitors

- Students will also learn to appreciate how enzymes are regulated and the physiological importance of enzyme regulation in the cell

- The course will introduce students to the applications of enzymes in research and medicine as well as in industry, which will bolster their foray into industrial and biomedical research.

### *Content/ Syllabus: Unit wise course content distribution*

**Unit -1: Introduction to enzymes**

Nature of enzymes - protein and non-protein (ribozyme). Cofactor and prosthetic group, apoenzyme, holoenzyme. IUBMB classification of enzymes.

**Unit-2: Features of enzyme catalysis**

Factors affecting the rate of chemical reactions, collision theory, activation energy and transition state theory, catalysis, reaction rates and thermodynamics of reaction. Catalytic power and specificity of enzymes (concept of active site), Fischer's lock and key hypothesis, Koshland's induced fit hypothesis.

**Unit -3: Enzyme kinetics**

Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant - monosubstrate reactions. Michaelis-Menten equation, Lineweaver-Burk plot, Eadie-Hofsteeand Hanes plot. Km and Vmax, Kcat and turnover number. Effect of pH, temperature and metal ions on the activity of enzyme.

**Unit - 4: Bisubstrate reactions**

Types of bi bi reactions (sequential – ordered and random, ping pong reactions). Differentiating bi substrate mechanisms (diagnostic plots, isotope exchange).

**Unit -5: Enzyme inhibition**

Reversible inhibition (competitive, uncompetitive, non-competitive, mixed and substrate). Mechanism based inhibitors - antibiotics as inhibitors.

**Unit – 6: Mechanism of action of enzymes**

General features - proximity and orientation, strain and distortion, acid base and covalent catalysis (chymotrypsin, lysozyme). Metal activated enzymes and metalloenzymes, transition state analogues.

**Unit -7: Regulation of enzyme activity**

Control of activities of single enzymes (end product inhibition) and metabolic pathways, feedback inhibition (aspartate transcarbomoylase), reversible covalent modification phosphorylation (glycogen phosphorylase). Proteolytic cleavage- zymogen. Multienzyme complex as regulatory enzymes. Occurrence and isolation, phylogenetic distribution and properties (pyruvate dehydrogenase, fatty acyl synthase) Isoenzymes - properties and physiological significance (lactate dehydrogenase).

**Unit -8: Involvement of coenzymes in enzyme catalysed reactions**

TPP, FAD, NAD, pyridoxal phosphate, biotin, coenzyme A, tetrahydrofolate, lipoic acid.

**Unit – 9: Applications of enzymes**

Application of enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases), enzyme immunoassay (HRPO), enzyme therapy (Streptokinase). Immobilized enzymes.

**PRACTICAL: Marks 50**

1.Partial purification of acid phosphatase from germinating mung bean.

2.Assay of enzyme activity and specific activity, e.g. acid phosphatase.

3.Effect of pH on enzyme activity

4.Determination of Km and Vmax using Lineweaver-Burk graph.

## *References/ Suggested Readings*

1.Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13: 978-1-4641-0962-1 / ISBN:10:1-4292-3414-8.

2.Biochemistry (2011) 4th ed., Donald, V. and Judith G.V., John Wiley & Sons Asia Pvt. Ltd. (New Jersey), ISBN:978-1180-25024.

3.Fundamentals of Enzymology (1999) 3rd ed., Nicholas C.P. and Lewis S., Oxford University Press Inc. (New York), ISBN:0 19 850229 X.

**Semester- IV**

**Major Paper**

**Course Name: Metabolism of Carbohydrates and Lipids**
**Course Code: BSCBCMMJ401**

| **Course Type: MAJOR(MJC)** | **Course Details: MJC-5** | | | **L-T-P: 3-0-4** | |
|---|---|---|---|---|---|
| **Credit: 5** | **Full Marks: 100** | **CA Marks** | | **ESE Marks** | |
| | | **Practical** | **Theoretical** | **Practical** | **Theoretical** |
| | | **30** | **15** | **20** | **35** |

Course Learning Outcomes After completion of the course, a student will learn

***Learning Objectives:***

1. Exposure with the nature of various biomolecules present in living cells.
2. Get exposed to key contributions of scientists such as Hans Krebs, G. N. Ramachandran, Melvin Calvin, Louis Pasteur, Har Gobind Khorana, Watson and Crick and Venky Ramakrishnan, etc. in order to create scientific interestamongst
3. students in life processes.
4. To understand the properties of carbohydrates, proteins, lipids, cholesterol, DNA,
5. RNA, glycoproteins and glycolipids and their importance in biologicalsystems.
6. To develop skills to determine amino acid and nucleotide sequences of proteins and DNArespectively.

***Content/ Syllabus: Unit wise course content distribution***

**Unit 1 Basic design of metabolism**

Autotrophs, heterotrophs, metabolic pathways, catabolism, anabolism, ATP as energy currency, reducing power of the cell.

**Unit 2 Glycolysis**
Glycolysis - a universal pathway, reactions of glycolysis, fermentation, fates of pyruvate, feeder pathways for glycolysis, galactosemia.

**Unit 3 Gluconeogenesis and pentose phosphate pathway**
Synthesis of glucose from non-carbohydrate sources, reciprocal regulation of glycolysis and gluconeogenesis, pentose phosphate pathway and its importance.
**Unit 4 Glycogen metabolism**
Glycogenesis and glycogenolysis, regulation of glycogen metabolism, glycogen storage diseases.

**Unit 5 Citric acidcycle**
Production of acetyl CoA, reactions of citric acid cycle, anaplerotic reactions, amphibolic role, regulation of citric acid cycle, glyoxylate pathway, coordinated regulation of glyoxylate and citric acidpathways.

**Unit 6 Synthesis of carbohydrates**
Calvin cycle, regulation of Calvin cycle, regulated synthesis of starch and sucrose, photorespiration, C4 and CAM pathways, synthesis of cell wall polysaccharides, integration of carbohydrate metabolism in plant cell.

**Unit 7 Fatty acid oxidation**
Digestion, mobilisation and transport of cholesterol and triacyl glycerol's, fatty acid transport to mitochondria, β oxidation of saturated, unsaturated, odd and even numbered and branched chain fatty acids, regulation of fatty acid oxidation, peroxisomal oxidation, ω oxidation, ketone bodies metabolism, ketoacidosis.

**Unit 8 Fatty acid synthesis**
Fatty acid synthase complex. Synthesis of saturated, unsaturated, odd and even chain fatty acids and regulation.

**Unit 9 Biosynthesis of cholesterol, steroids and isoprenoids**
Synthesis of prostaglandins, cholesterol, steroids and isoprenoids. Regulation of cholesterol synthesis.

**Unit 10 Biosynthesis of membrane lipids**
Synthesis of membrane phospholipids in prokaryotes and eukaryotes, respiratory distress syndrome, biosynthesis of triacylglycerol, biosynthesis of plasmalogens, sphingolipids and glycolipids, lipid storage diseases.

**Unit 11 Starve-feed cycle**
Well-fed state, early fasting state, fasting state, early re-fed state, energy requirements, reserves and caloric homeostasis, five phases of glucose homeostasis.

**PRACTICALS : Marks 50**

1. Exposure to basic reactions of biomolecules.
2. Determine presence of biomolecules like carbohydrates, proteins, lipids, etc. in known and unknown sample.
3. Determine the extent of adulteration in samples containing biomolecules.

### *Content/ Syllabus: Unit wise course content distribution:*

1. Estimation of blood glucose (spectrophotometric/colorimetricmethod).

2. Sugar fermentation of microorganisms.

3. Assay of salivary amylase.

4. Isolation of lecithin from egg yolk, identification byTLC.

5. Isolation of cholesterol from egg yolk and itsestimation.

### *References/ Suggested Readings*

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 /ISBN:10:1-4641-0962-1.

2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New Jersey),ISBN:978-0-470-28173-4.

3. Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5,ISBN:13:978-1-4292-2936-4.

**Semester- IV**

**Major Paper**

**Course Name: Membrane Biology and Bioenergetics**
**Course Code: BSCBCMMJ402**

| **Course Type: MAJOR(MJC)** | **Course Details: MJC-6** | | | **L-T-P: 3-0-4** | |
|---|---|---|---|---|---|
| **Credit: 5** | **Full Marks: 100** | **CA Marks** | | **ESE Marks** | |
| | | **Practical** | **Theoretical** | **Practical** | **Theoretical** |
| | | **30** | **15** | **20** | **35** |

Course Learning Outcomes After completion of the course, a student will learn

***Learning Objectives:***

1. Understanding of the fundamental aspects of composition, structure and functioning of biological membranes and energy transformation in livingorganisms.

2. Ability to state the laws of chemical thermodynamics, to describe the main terms, to understand energetical processes in living cells, biological role of membrane structures, and the associated energy transformationmechanisms.

3. Ability to describe ways of energy transformation in animal and plant cells, archaea and bacteria, to describe the membrane transport mechanisms; to describe the process of synthesis of ATP by chemiosmosis.

4. Ability to understand how artificial membranes are prepared, to describe the applications and limits of the membrane research methods.

***Content/ Syllabus: Unit wise course content distribution:***

**Unit 1 Introduction to bio membranes**

Composition of bio membranes - prokaryotic, eukaryotic, subcellular membranes. Study of membrane proteins. Fluid mosaic model with experimental proof.

**Unit 2 Membrane structures**
Polymorphic structures of amphiphilic molecules in aqueous solutions - micelles and bilayers. Membrane asymmetry. Macro and micro domains in membranes. Membrane skeleton. RBC membranearchitecture.

**Unit 3 Membrane dynamics**
Lateral, transverse and rotational motion of lipids and proteins. Transition studies of lipid bilayer.
Membrane fluidity, factors affecting membrane fluidity.

**Unit 4 Membrane transport**
Thermodynamics of transport. Simple diffusion and facilitated diffusion. Passive transport-glucose transporter, anion transporter and porins**.** Primary and secondary active transporters. Na+-glucose symporter. ABC family of transporters. Group translocation. Ion channels - voltage-gated ion channels (Na+/K+ voltage-gated channel), ligand-gated ion channels (acetyl choline receptor), aquaporins, bacteriorhodopsin. Ionophores - valinomycin, gramicidin.

**Unit 5 Introduction to bioenergetics**
Laws of thermodynamics, state functions, equilibrium constant, coupled reactions, energy charge, ATP cycle, phosphorylation potential, phosphoryl group transfers. Chemical basis of high standard energy of hydrolysis of ATP, other phosphorylated compounds and thioesters. Redox reactions, standard redox potentials. Universal electron carriers.

**Unit 6 Oxidative phosphorylation**
Mitochondria. Electron transport chain (ETC) - its organization and function. Inhibitors of ETC and uncouplers. Mitchell's chemiosmotic hypothesis. Proton motive force. $F_oF_1$ATP synthase, structure and mechanism of ATP synthesis. Metabolite transporters in mitochondria. Regulation of oxidative phosphorylation. ROS production and antioxidant mechanisms. Thermogenesis. Alternative respiratory pathways inplants.

**Unit 7 Photophosphorylation**
General features of photophosphorylation, historical background, Hill reaction, photosynthetic pigments, light harvesting systems of plants and microbes and resonance energy transfer. Bacterial photophosphorylation in purple bacteria, green sulfur bacteria. Photophosphorylation in plants - structure of chloroplast, molecular architecture of Photosystem I and Photosystem II, Z-scheme of photosynthetic electron flow, oxygen evolving complex and action of herbicides. Cyclic photophosphorylation and its significance. Evolution of oxygenicphotosynthesis.

**PRACTICALS: Marks 50**

***Content/ Syllabus: Unit wise course content distribution:***

1. Determination of CMC of detergents.

2. RBC ghost cell preparation and to study the effect of detergents on membranes.

3. Separation of photosynthetic pigments by TLC.

4. Study photosynthetic O2 evolution in hydrilla plant.

5. Isolation of chloroplast from spinach leaves, estimation of chlorophyll and photosynthetic activity.

### *References/ Suggested Readings:*

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13:978-1-4641-0962-1 /ISBN:10:1-4641-0962-1.

2. Molecular Cell Biology (2013) 7th ed., Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Scott, M.P., W.H. Freeman & Company (New York), ISBN:13:978-1-4641-0981-2.

3. Biochemistry (2010) 4th ed., Garret, R. H. and Grisham, C.M., Cengage Learning (Boston),ISBN-13:978-0-495-11464-2.

4.sssPrinciples of Biochemistry (2008) 3rd ed., Voet, D.J., Voet, J.G. and Pratt, C.W., John Wiley & Sons, Inc. (New York), ISBN:13:978-0470-23396-2