

**Syllabus of Biochemistry (Hons.)  
for SEM-I & SEM-II under CBCS  
(to be effective from  
Academic Year: 2017-18)**



**The University of Burdwan  
Burdwan, West Bengal**

## **1. Introduction**

The syllabus for Biochemistry at undergraduate level using the Choice Based Credit system has been framed in compliance with model syllabus given by UGC.

The main objective of framing this new syllabus is to give the students a holistic understanding of the subject giving substantial weight age to both the core content and techniques used in Biochemistry.

The ultimate goal of the syllabus is that the students at the end are able to secure a job. Keeping in mind and in tune with the changing nature of the subject, adequate emphasis has been given on new techniques of mapping and understanding of the subject.

The syllabus has also been framed in such a way that the basic skills of subject are taught to the students, and everyone might not need to go for higher studies and the scope of securing a job after graduation will increase.

It is essential that Biochemistry students select their general electives courses from Chemistry, Physics, Mathematics and/or any branch of Life Sciences disciplines.

While the syllabus is in compliance with UGC model curriculum, it is necessary that Biochemistry students should learn “Basic Microbiology” as one of the core courses rather than as elective while. Course on “Concept of Genetics” has been moved to electives.

Also, it is recommended that two elective courses namely Nutritional Biochemistry and Advanced Biochemistry may be made compulsory.

### Type of Courses

Course type	Description	Number of Courses
		B. Sc. (Honours)
CC	Core Course	14
DSE	Discipline Specific Elective	4
GE	Generic Elective	4
AECC (ENVS & ENGLISH/MIL)	Ability Enhancement Compulsory Course	2
SEC	Skill Enhancement Course	2
<b>TOTAL CREDIT</b>		<b>142</b>

## Structure at a glance for Biochemistry (H) at UG level, B.U.:

### 1<sup>st</sup> Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-1	Molecules of Life (Theo) Molecules of Life (Prac)	Core Course – I	4+2	75
CC-2	Cell Biology (Theo) Cell Biology (Prac)	Core Course – II	4+2	75
GE-1	Biochemistry of Cell (Theo + Prac)	Generic Elective – 1	4+2	75
AECC-1	ENVS	Ability Enhancement Compulsory Course – I	4	100
<b>TOTAL</b>			<b>22</b>	<b>325</b>

### 2<sup>nd</sup> Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-3	Proteins (Theo) Proteins (Prac)	Core Course – III	4+2	75
CC-4	Enzymes (Theo) Enzymes (Prac)	Core Course – IV	4+2	75
GE-2	Proteins and Enzymes (Theo + Prac)	Generic Elective – 2	4+2	75
AECC-2	Communicative Eng./MIL	Ability Enhancement Compulsory Course – II	2	50
<b>TOTAL</b>			<b>20</b>	<b>275</b>

### 3<sup>rd</sup> Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-5	Metabolism of Carbohydrates and Lipids (Theo) Metabolism of Carbohydrates and Lipids (Prac)	Core Course – V	4+2	75
CC-6	Physiology and Hormones (Theo) Physiology and Hormones (Prac)	Core Course – VI	4+2	75
CC-7	Physical Biochemistry (Theo) Physical Biochemistry (Prac)	Core Course – VII	4+2	75
SEC-1	Clinical Biochemistry or Bioinformatics and Biostatistics	Skill Enhancement Course – 1	2	50
GE-3	Fundamentals of Cell Biology and Immunology	Generic Elective – 3	4+2	75
<b>TOTAL</b>			<b>26</b>	<b>350</b>

### 4<sup>th</sup> Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-8	Membrane Biology and Bioenergetics (Theo) Membrane Biology and Bioenergetics (Prac)	Core Course – VIII	4+2	75
CC-9	Metabolism of Amino Acid and Nucleic Acid (Theo) Metabolism of Amino Acid and Nucleic Acid (Prac)	Core Course – IX	4+2	75
CC-10	Basic Microbiology and Microbial Genetics (Theo) Basic Microbiology and Microbial Genetics (Prac)	Core Course - X	4+2	75
SEC-2	Techniques in Biochemistry or Protein Purification Techniques	Skill Enhancement Course – II	2	50
GE-4	Fundamentals of Genetic Engineering	Generic Elective – 4	4+2	75
<b>TOTAL</b>			<b>26</b>	<b>350</b>

**5<sup>th</sup> Semester**

Course Code	Course Title	Course Type	Credit per course	Marks
CC-11	Chromosome organization, DNA replication, Mutation and Repair (Theo) Chromosome organization, DNA replication, Mutation and Repair (Prac)	Core Course – XI	4+2	75
CC-12	Gene expression and regulation (Theo) Gene expression and regulation (Prac)	Core Course – XII	4+2	75
DSE-1	Nutritional Biochemistry (Theo + Prac) or Concept of Genetics (Theo + Prac)	Discipline Specific Elective	4+2	75
DSE-2	Infectious and Non-infectious Diseases (Theory) or Advanced Biochemistry (Theory)	Discipline Specific Elective	6	75
<b>TOTAL</b>			<b>24</b>	<b>300</b>

**6<sup>th</sup> Semester**

Course Code	Course Title	Course Type	Credit per course	Marks
CC-13	Recombinant DNA Technology and Genetic Engineering (Theo) Recombinant DNA Technology and Genetic Engineering (Prac)	Core Course – XIII	4+2	75
CC-14	Immunology (Theo) Immunology (Prac)	Core Course – XIV	4+2	75
DSE-3	Neuro Biochemistry (Theo) or Molecular Diagnostics (Theo + Prac)	Discipline Specific Elective	6 or 4+2	75
DSE-4	Project Work or Dissertation followed by power point presentation	Discipline Specific Elective	6	75
<b>TOTAL</b>			<b>24</b>	<b>300</b>

## 1<sup>st</sup> Semester:

**Course Code: CC-1**

**Course Title: Molecules of Life (Theo)**

4 Credits

*The foundations of biochemistry: Cellular and chemical foundations of life*

### **Water**

Unique properties, weak interactions in aqueous systems, ionization of water, water as a reactant and fitness of the aqueous environment. 02 lectures

### **Basic principles of Inorganic, Organic & Physical Chemistry**

- Atomic structure and atomic properties:

Modern form of periodic table, periodicities of atomic-, ionic- and van der Waals radii, ionization energy, electron affinity, electronegativity, ionic potential. 03 lectures

- Chemical bonding:

Ionic bond, covalent bond, metallic bond, deformation of ions and Fajan's rule, hydrogen bonding, van der Waals' force, dipole moment, bond polarity. 03 lectures

- Redox properties:

Standard electrode potential, formal potential, complex formation and precipitation reaction on formal potential, disproportionation and comproportionation reactions. 03 lectures

- Metal ions in living systems:

Essential elements, toxic elements and their toxicities, classification of biological metal ions and ligands according to HSAB principle, chelation therapy. 03 lectures

- Bonding and stereochemistry: 03 lectures

Hybridisation of carbon ( $sp^3$ ,  $sp^2$ ,  $sp$ ), localized and delocalized bonds, inductive effect, field effect, electromeric effect, conjugation, resonance, hyperconjugation, tautomerism, aromaticity.

- Organic reaction mechanism: 05 lectures

Classification of reagents (nucleophile, electrophile, free radical, regioselective and chemoselective), thermodynamics and kinetics of organic reactions, energy profiles: intermediate and transition state, substitution reactions ( $S_N1$ ,  $S_N2$ ), elimination reaction ( $E1$ ,  $E2$ ,  $E1CB$ ).

- Stereochemistry of carbon compounds

configuration and conformation of organic molecules, dihedral angle and angle of torsion – gauche, eclipsed and staggered arrangement, elementary idea about the conformational analysis of cyclohexane and its mono- and di-substituted derivatives (chair, boat and twist boat forms), Fisher, Newman, Sawhorse & Flying-wedge representation, configurational nomenclature – D/L, R/S; enantiomer, diastereomer, mesomer, racemic mixture, optical activity, optical isomerism, optical rotation, resolution of optical isomers. 06 lectures

- Biophysical properties

*Viscosity*: General features of fluid flow (streamlined and turbulent), nature of viscous drag for streamlined motion, Definition of viscosity coefficient, Origin of viscosity of liquids, expression for viscosity coefficient of liquids (no derivation): Poiseuille's equation, temperature dependence of viscosity coefficient of liquids, Stoke's law and terminal velocity, Determination of viscosity coefficient of liquids, Diffusion of solutes in solution, Fick's law. 05 lectures

*Surface tension*: Definition, angle of contact, interfacial tension, capillary rise, determination of surface tension, temperature effect. 03 lectures

*Preliminary idea of Chemical equilibrium*: Equilibrium constant, Le Chatelier's principle and its simple applications. Ionic equilibrium: Standard solution, Molar, Normal, Molal, Formal and percent strengths, Hydrolysis of weak acids and bases. pKa, pKb, pH, pOH acid- base neutralization curves, Buffer action definition, Henderson -Hasselbalch equation and preparation of buffers, buffer capacity, Solubility product principle and application. 04 lectures

*Electrochemistry*: Electrical conductance, cell constant, specific conductance and equivalent conductance., Variation of equivalent conductance of strong and weak electrolytes with dilution, Kohlrausch's law of independent migration of ions, ion conductance and ionic mobility, Equivalent conductance at infinite dilution for weak electrolytes and determination of dissociation constants of weak electrolytes from conductance measurements. EMF of cell (no derivation). 05 lectures



## **Lipids**

Brief idea about lipids: fatty acids, triglycerides, P-lipids, sphingosine, ceramide, sphingomyelin, sterols and cholesterol, glycolipids, sphingolipids, (blocks of lipids - fatty acids, glycerol, ceramide. Storage lipids - triacyl glycerol and waxes). Structural Lipids in biological membranes – Phospholipases: phospholipase A2, phospholipase C, phospholipase D, Inositol tris- phosphate and diacyl glycerol as signaling molecules. 05 lectures

## **Amino Acids**

Structure and classification, essential and non essential amino acids, physical, chemical and optical properties of amino acids. 04 lectures

## **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 nucleic acids. Other functions of nucleotides – source of energy, component of coenzymes. 06 lectures

## **Reference Books**

1. Outlines of Biochemistry: Conn and Stumpf
2. Biochemistry: Debojyoti Das
3. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H.
4. Freeman and Company (New York), ISBN: 13: 978-1-4641-0962-1 / ISBN: 10:1-4292-3414-
5. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4.
6. 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.
7. Fundamental of Biochemistry, Voet and Voet.
8. *General and Inorganic Chemistry*, R. Sarkar, Part I, 2<sup>nd</sup> Edition, New Central Book Agency, Kolkata.
9. *Inorganic Chemistry*, R. L. Dutta, Part I, The New Book Stall, Kolkat.
10. *Bioinorganic Chemistry*, A. K. Das, Books and Allied (P) Ltd, Kolkata.
11. *Organic Chemistry*, I. L. Finar Volumes 1 and 2: Stereochemistry and chemistry of natural products, 5th Edition, ELBS.

12. *Organic Chemistry*, T. W. G. Solomons, C. B. Fryhle, S. A. Snyder, 11<sup>th</sup> Edition (International Student Version), Wiley.
13. *A Guide Book to Mechanism of Organic Chemistry*, P. Sykes, 6<sup>th</sup> Edition, Pearson.
14. *Physical Chemistry*, P. C. Rakshit, Sarat Book House, Kolkata.
15. *Physical Chemistry*, I. N. Levine, Tata McGraw-Hill.

**Course Code: CC-1**

**Course Title: Molecules of Life (Prac.)**

2 Credits

*List of Practical:*

1. Safety measures in laboratories, use and calibration of pipettes.
2. Preparation of normal, molar solutions and percent solutions.
3. Concept of pH and preparation of buffers.
4. Determination of pK<sub>a</sub> of acetic acid and glycine.
5. Separation of amino acids by paper chromatography.
6. Separation of lipids by thin layer chromatography.

**Course Code: CC-2**

**Course Title: Cell Biology (Theo)**

4 Credits

Cells: Prokaryotic (archaea and eubacteria) and eukaryotic cell (animal and plant cells).

05 lectures

*Subcellular organelles and membranes*

Cell membrane-peripheral and integral membrane proteins. Structure of biological membranes – Gorter & Grendel Model, Danielli and Davson model, Unit membrane model and Singer and Nicolson model, Nucleus, lysosomes, endoplasmic reticulum, Golgi bodies, mitochondria, chloroplast, perixysomes, cell wall. Endosymbiont hypothesis of the biogenesis of mitochondria and chloroplast, Marker enzymes and proteins of subcellular organelles, and their membranes, cytosol and cell membrane.

15 lectures

*Cytoskeletal proteins*

Structure and organization of actin filaments. 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.

10 lectures

*Functional proteins*

Outline of structural proteins, transport proteins and immunoglobulins. 03 lectures

*Cell wall and extracellular matrix*

Prokaryotic and eukaryotic cell wall, cell matrix proteins. Cell-matrix interactions and cell-cell interactions. Adherence junctions, tight junctions, gap junctions, desmosomes, hemidesmosomes, focal adhesions and plasmodesmata. 07 lectures

*Protein trafficking*

Regulation of nuclear protein import and export. Import and export of proteins and lipids in ER. Protein sorting and processing in Golgi. Mechanism of vesicular transport – the Dolichol phosphate pathway. 10 lectures

*Cell cycle, cell death and cell renewal*

Eukaryotic cell cycle and its Regulation. Cell division. Outline on apoptosis and necrosis. 03 lectures

*Tools of Cell Biology*

Cells as experimental models, Light microscopy, phase contrast microscopy, fluorescence microscopy, confocal microscopy, electron microscopy, FACS, Differential and density gradient centrifugation for subcellular fractionations. 07 lectures

**Reference Books:**

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), and 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.
4. Enlarge, M., Garland Science (Princeton), ISBN: 0-8153-1619-4 / ISBN: 0-8153-1620-8.

**Course Code: CC-2**

**Course Title: Cell Biology (Prac.)**

2 Credits

*List of Practical*

1. Visualization of animal and plant cells by methylene blue & Micrographs of different cell components and study of mitosis and meiosis from permanent slides (dry lab);
2. Identification of different stages of mitosis in onion root tip;
3. Identification of different stages of meiosis in grasshopper testis/ onion flower bud anthers;
4. Isolation of different sub-organelles and their identification by respective marker enzyme/protein;
5. Staining and visualization of mitochondria by Janus green stain: &
6. Identification of live cells by Trypan blue exclusion test.

**Course Code: Generic Elective-1 (Theo.)**

4 Credits

**[Only for the students of Biochemistry (Hons.)]**

**Course Title: Biochemistry of Cell**

*Biomolecules in their cellular environment*

The cellular basis of life. Cellular structures – prokaryotes and eukaryotes. Chemical principles in biomolecular structure. Major classes of biomolecules. Role of water in design of biomolecules. 12 lectures

*Amino acids and peptides*

Types of amino acids and their chemistry, derivatives of amino acids and their biological role. Introduction to biologically important peptides. 08 lectures

*Sugars and polysaccharides*

Basic chemistry of sugars, optical activity. Disaccharides, trisaccharides and polysaccharides - their distribution and biological role. 08 lectures

*Nucleosides, nucleotides and nucleic acids*

Structures and chemistry, DNA structures and their importance, different types of RNA. Unusual DNA structures, other functions of nucleotides. 08 lectures

### *Lipids*

Various classes of lipids and their distribution, storage lipids, structural lipids in membranes, lipids as signals, cofactors and pigments. 08 lectures

### *Vitamins, coenzymes and metal ions*

Occurrence and nutritional role. Coenzymes and their role in metabolism, metal ion containing biomolecules, heme, porphyrins and cyanocobalamin – their biological significance. 8 lectures

### *Signalling Molecules*

Second messengers - cAMP, cGMP, IP3, diacyl glycerol, Ca<sup>2+</sup>, NO. Brief account of their importance and role in signalling and signal transduction. 08 lectures

### **References:**

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: 10-14641-0962-1.
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.

**Course Code: Generic Elective-1 (Prac.)**

2 Credits

**[Only for the students of Biochemistry (Hons.)]**

**Course Title: Biochemistry of Cell**

### *List of Practical*

1. General safety procedures in a laboratory. Calibration and Use of auto pipettes.
2. Making solutions and buffer preparation - acetate and tris buffers.
3. Qualitative tests for biomolecules - carbohydrates, lipids, amino acids, proteins, bases and nucleic acids.
4. Separation of amino acids by paper chromatography.
5. Estimation of ascorbic acid in fruit juices.

## 2<sup>nd</sup> Semester:

**Course Code: CC-3**

**Course Title: Proteins (Theo)**

4 Credits

*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 (Specific examples of Proteins/Peptides may be included under each category). 12 lectures

*Extraction, Separation and Characterization of Proteins*

Solubilization of proteins from their cellular and extracellular locations. Use of simple grinding methods, homogenization and centrifugation. Ammonium sulphate fractionation, solvent fractionation, dialysis and lyophilisation. Ion- exchange chromatography, molecular sieve chromatography, hydrophobic interaction/reverse phase chromatography, affinity chromatography, HPLC and FPLC.

Determination of purity, molecular weight, extinction coefficient and sedimentation coefficient, IEF, SDS-PAGE and 2-D electrophoresis. 20 lectures

*. Covalent structure of proteins*

Organization of protein structure into primary, secondary, tertiary and quaternary structures. 03 lectures

*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 plot. Techniques used in studying 3-D structures - X-ray diffraction and NMR (introductory). Motifs and domains. 10 lectures

*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 and associated diseases --- Alzheimer's disease. 07 lectures

### *Myoglobin and haemoglobin and Membrane Proteins*

Structures of myoglobin and haemoglobin, Oxygen binding curves, influence of 2,3-Biphosphoglyceric acid, CO<sub>2</sub> and Cl<sup>-</sup>. Hill plot. Cooperativity between subunits and models to explain the phenomena – concerted and sequential models. Haemoglobin disorders and associated diseases – sickle cell anemia, and thalasemia. 08 lectures

#### **Reference Books:**

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. 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.

#### **Course Code: CC-3**

#### **Course Title: Proteins (Prac.)**

2 Credits

#### *List of practical*

1. Verification of Lambert-Beer's Law
2. Estimation of proteins using UV absorbance and Biuret method.
3. Assay of proteins using Lowry/Bradford method, standard curve preparation.
4. Determination of Isoelectric pH of glycine and alanine.
5. Determination of molecular mass of protein by SDS-PAGE using bovine serum albumin as the standard.

**Course Code: CC-4**

**Course Title: Enzymes (Theo)**

4 Credits

*Introduction to Enzymes*

Nature of enzymes - protein and non-protein (ribozyme). Cofactor and prosthetic group, apoenzyme, holoenzyme. IUBMB classification of enzymes. 07 lectures

*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. 10 lectures

*Enzyme Kinetics*

Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant - monosubstrate reactions. Michaelis-Menten equation, Lineweaver- Burk plot, Eadie-Hofstee and Hanes plot.  $K_m$  and  $V_{max}$ ,  $K_{cat}$  and turnover number. Effect of pH, temperature and metal ions on the activity of enzyme. 13 lectures

*Enzyme inhibition*

Reversible inhibition (competitive, uncompetitive, non-competitive, mixed and substrate). Mechanism based inhibitors - antibiotics as inhibitors. 05 lectures

*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. 07 lectures

*Regulation of enzyme activity*

Control of activities of single enzymes (end product inhibition) and metabolic pathways, feedback inhibition, allosteric regulation (aspartate transcarbamoylase), 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). 13 lectures



*Involvement of coenzymes in enzyme catalysed reactions*

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

05 lectures

**Reference Books:**

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.
4. Enzymes, (1973), Malcolm Dixon, Edwin Clifford Webb, Prentice Hall Press, ISBN: 0 58 2462177.
5. Biochemical Calculations, (1976) 3rd ed., Irwin H. Segel, John Wiley and Sons ISBN: 0 47 1774219

**Course Code: CC-4**

**Course Title: Enzymes (Prac)**

2 Credits

*List of practical*

1. Purification of alkaline phosphatase from germinating mung bean.
2. Assay of enzyme activity and specific activity of alkaline phosphatase.
3. Effect of pH on enzyme activity
4. Determination of  $K_m$  and  $V_{max}$  using Lineweaver-Burk graph.
5. Zymogram assay of protein.

**Course Code: Generic Elective-2 (Theo)**

4 Credits

**[Only for the students of Biochemistry (Hons.)]**

**Course Title: Proteins and Enzymes**

*Introduction to proteins*

Polypeptides and proteins. Subunit structures, conjugated proteins, diversity of function.

05 lectures

*Isolation and analysis of proteins*

Techniques to isolate and analyze proteins- salt fractionation, ion-exchange chromatography, gel permeation, HPLC, SDS-PAGE, and IEF. Protein primary structure - sequencing by Edman degradation, use of enzymes and chemical reagents to obtain overlap peptides. Synthesis of peptides using Merrifield method.

15 lectures

*Introduction to protein three-dimensional structures*

Secondary structure- helices and sheets, Ramachandran maps. Nature of non-covalent bonds and covalent bonds in protein folding. Tertiary and quaternary structures.

07 lectures

*Myoglobin and haemoglobin - structure and function*

Oxygen binding curves, cooperativity models for haemoglobin.

03 lectures

*Introduction to enzyme catalysis*

Features of enzyme catalysis, superior catalytic power. General mechanisms of catalysis. Nomenclature.

05 lectures

*Enzyme Kinetics*

Principles of reaction rates, order of reactions and equilibrium constants. Derivation of Michaelis-Menten equation. Significance of  $K_m$  and  $V_{max}$ . Catalytic efficiency parameters. Competitive and mixed inhibitions. Kinetics and diagnostic plots. Types of irreversible inhibitors.

15 lectures

*Mechanisms of enzyme action and regulation*

Mechanism of action of chymotrypsin. Inhibitors of enzymes - antibiotics. Allosteric Regulation of enzyme activity and its importance - aspartate transcarbamoylase.

05 lectures

*Enzymes in medicine and industry*

Enzymes used in clinical biochemistry as reagents, diagnostics and therapy. Role of immobilized enzymes in industry. 05 lectures

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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: 10-14641-0962-1.
2. Fundamentals of Enzymology (1999) 3rd ed., Price, N.C and Stevens, L., Oxford University Press Inc., (New York), ISBN:13: 978-0-19-806439-8.

**Course Code: Generic Elective-2 (Prac.)**

**2 Credits**

**[Only for the students of Biochemistry (Hons.)]**

**Course Title: Proteins and Enzymes**

***List of Practical***

1. Protein estimation by UV absorbance and Biuret method.
2. Protein microassay by Lowry/Bradford method.
3. Ammonium sulphate fractionation of crude homogenate from germinated mung bean.
4. Setting up assay for alkaline phosphatase and activity measurements of the ammonium sulphate fractions (progress curve and effect of pH).
5. Determination of  $K_m$  and  $V_{max}$  of enzyme enriched fraction.

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**Syllabus of Biochemistry (Hons.)  
for SEM-III & SEM-IV under  
CBCS**

**(to be effective from  
Academic Year: 2017-18)**



**The University of Burdwan  
Burdwan, West Bengal**

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## Type of Courses

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<b>TOTAL CREDIT</b>		<b>142</b>

## Structure at a glance for Biochemistry (H) at UG level, B.U.:

### 1<sup>st</sup> Semester

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AECC-1	ENVS	Ability Enhancement Compulsory Course – I	4	100
<b>TOTAL</b>			<b>22</b>	<b>325</b>

### 2<sup>nd</sup> Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-3	Proteins (Theo) Proteins (Prac)	Core Course – III	4+2	75
CC-4	Enzymes (Theo) Enzymes (Prac)	Core Course – IV	4+2	75
GE-2	Proteins and Enzymes (Theo + Prac)	Generic Elective – 2	4+2	75
AECC-2	Communicative Eng./MIL	Ability Enhancement Compulsory Course – II	2	50
<b>TOTAL</b>			<b>20</b>	<b>275</b>

### 3<sup>rd</sup> Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-5	Metabolism of Carbohydrates and Lipids (Theo) Metabolism of Carbohydrates and Lipids (Prac)	Core Course – V	4+2	75
CC-6	Physiology and Hormones (Theo) Physiology and Hormones (Prac)	Core Course – VI	4+2	75
CC-7	Physical Biochemistry (Theo) Physical Biochemistry (Prac)	Core Course – VII	4+2	75
SEC-1	Clinical Biochemistry or Bioinformatics and Biostatistics	Skill Enhancement Course – 1	2	50
GE-3	Fundamentals of Cell Biology and Immunology	Generic Elective – 3	4+2	75
<b>TOTAL</b>			<b>26</b>	<b>350</b>

### 4<sup>th</sup> Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-8	Membrane Biology and Bioenergetics (Theo) Membrane Biology and Bioenergetics (Prac)	Core Course – VIII	4+2	75
CC-9	Metabolism of Amino Acid and Nucleic Acid (Theo) Metabolism of Amino Acid and Nucleic Acid (Prac)	Core Course – IX	4+2	75
CC-10	Basic Microbiology and Microbial Genetics (Theo) Basic Microbiology and Microbial Genetics (Prac)	Core Course - X	4+2	75
SEC-2	Techniques in Biochemistry or Protein Purification Techniques	Skill Enhancement Course – II	2	50
GE-4	Fundamentals of Genetic Engineering	Generic Elective – 4	4+2	75
<b>TOTAL</b>			<b>26</b>	<b>350</b>



5<sup>th</sup> Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-11	Chromosome organization, DNA replication, Mutation and Repair (Theo) Chromosome organization, DNA replication, Mutation and Repair (Prac)	Core Course – XI	4+2	75
CC-12	Gene expression and regulation (Theo) Gene expression and regulation (Prac)	Core Course – XII	4+2	75
DSE-1	Nutritional Biochemistry (Theo + Prac) or Concept of Genetics (Theo + Prac)	Discipline Specific Elective	4+2	75
DSE-2	Infectious and Non-infectious Diseases (Theory) or Advanced Biochemistry (Theory)	Discipline Specific Elective	6	75
<b>TOTAL</b>			<b>24</b>	<b>300</b>

6<sup>th</sup> Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-13	Recombinant DNA Technology and Genetic Engineering (Theo) Recombinant DNA Technology and Genetic Engineering (Prac)	Core Course – XIII	4+2	75
CC-14	Immunology (Theo) Immunology ( (Prac)	Core Course – XIV	4+2	75
DSE-3	Neuro Biochemistry (Theo) or Molecular Diagnostics (Theo + Prac)	Discipline Specific Elective	6 or 4+2	75
DSE-4	Project Work or Dissertation followed by power point presentation	Discipline Specific Elective	6	75
<b>TOTAL</b>			<b>24</b>	<b>300</b>

## 3<sup>rd</sup> Semester

**Course Code: CC-5**

**Course Title: Metabolism of Carbohydrates and Lipids (Theo)**

4 credits

### *Concept of Bioenergetics*

Entropy, enthalpy, free energy, catabolism, anabolism, ATP as energy currency, reducing power of the cell, metabolic pathways.

### *Glycolysis, Gluconeogenesis, pentose phosphate pathway and Glycogen metabolism*

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

Synthesis of glucose from non-carbohydrate sources, reciprocal regulation of glycolysis and gluconeogenesis, pentose phosphate pathway and its importance.

Glycogenesis and glycogenolysis, regulation of glycogen metabolism, glycogen storage diseases.

### *Citric acid cycle*

Production of acetyl CoA, reactions of citric acid cycle, anaplerotic reactions, amphibolic role, regulation of citric acid cycle, glyoxalate pathway, coordinated regulation of glyoxalate and citric acid pathways.

### *Fatty acid oxidation*

Digestion, mobilisation and transport of cholesterol and triacyl glycerols, fatty acid transport to mitochondria,  $\beta$  oxidation of saturated, unsaturated, odd and even numbered and branched chain fatty acids, regulation of fatty acid oxidation, peroxisomal oxidation,  $\omega$  oxidation, ketone body's metabolism, ketoacidosis.

### *Fatty acid synthesis*

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

*Biosynthesis of eicosanoids and cholesterol*

synthesis of prostagladins, leukotrienes and thromboxanes. Synthesis of cholesterol, regulation of cholesterol synthesis, integration of carbohydrate and lipid metabolism. Inborn errors of carbohydrate & lipid metabolism.

**Reference Books**

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.

**Course Code: CC-5**

**Course Title: Metabolism of Carbohydrates and Lipids (Prac.)**

2 Credits

***List of practical***

1. Qualitative tests for carbohydrates and lipids
2. Separation of sugars by paper & thin layer chromatography.
3. Assay of salivary amylase.
4. Isolation of cholesterol from egg yolk and its estimation.

**Course Code: CC-6**

**Course Title: Physiology and Hormones (Theo)**

4 credits

*Homeostasis and the organization of body fluid compartments*

Buffer system in blood, Intracellular, extracellular and interstitial fluid. Homeostasis, control system and their components. Plasma as an extracellular fluid, RBC, blood coagulation: mechanism, role of vitamin K in coagulation, anticoagulant and fibrinolytic systems. Anemias, polycythemia, haemophilia and thrombosis.

*Cardiovascular physiology, Respiration, Digestive & Excretory*

Physiology of the cardiac muscle, automaticity of the cardiac muscle contraction, excitation contraction coupling, control of cardiac function and output. Overview on digestive and excretory system, organization of the pulmonary system. Mechanism & regulation of breathing, pulmonary ventilation and related volumes, pulmonary circulation. Principles of gas exchange and transport. Regulation of respiration. Respiratory quotient.

*Introduction to endocrinology*

Hormones: Definitions & classifications, mode of secretion and transport of hormones in the circulation, Functions of hormones and their regulation. Endocrine, paracrine, autocrine, intracrine and neuroendocrine, Feedback Mechanism.

*Thyroid hormone*

Thyroid, hypothalamic and pituitary, Pancreatic, GI tract and adrenal hormones – their implications in health and diseases. Inborn errors associated with their dysregulation.

*Introduction to plant growth regulations*

Target cell, Receptor of plant hormones, Physiology and signalling of Auxins, ABA & C<sub>2</sub>H<sub>4</sub>.

*Plant photophysiology*

Basic mechanism of light absorption, Z-Scheme, PGRC, C<sub>4</sub>, CAM & C<sub>2</sub> cycle and their significance in photomorphogenesis, Blue light response in plants.

## Reference Books

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M. W.H. Freeman & Company (New York), ISBN: 10-14641-0962- 1.
2. Vander's Human Physiology (2008) 11th ed., Widmaier, E.P., Raff, H. and Strang, K.T. McGraw Hill International Publications, ISBN: 978-0-07-128366-3.
3. Endocrinology (2007) 6th ed., Hadley, M.C. and Levine, J.E. Pearson Education, ISBN: 978-81-317-2610-5.
4. The Cell: A Molecular Approach (2009) 5th Ed. Cooper, G.M. and Hausman, R.E. ASM Press & Sunderland, ISBN: 978-0-87893- 300-6.
5. Human Physiology (2016) 11th Ed., C. C. Chatterjee, CBS Publishers, ISBN: 10- 81239 2873-4.
6. Biochemistry (1978) 2nd Ed., Debajyoti Das, Academic Publishers.
7. Medical Physiology (2010) 12 Ed., Guyton and Hall, Saunders, ISBN: 10- 14160-4574-0.
8. Photomorphogenesis in Plants (1994) R. E. Kendrick and G. H. M. Kronenberg (Eds.), Springer.

**Course Code: CC-6**

**Course Title: Physiology and Hormones (Prac.)**

2 Credits

***List of Practical***

1. Estimation of haemoglobin.
2. Separation of plasma proteins.
3. Separation of isoenzymes of LDH by electrophoresis.
4. Estimation of serum  $\text{Ca}^{2+}$ .
5. Estimation of serum T4.

**Course Code: CC-7**

**Course Title: Physical Biochemistry (Theo)**

4 credits

*Introduction*

Special chemical requirement of biomolecules; factors affecting analyte structure and stability: pH, temperature and solvent polarity; buffering systems used in biochemistry, osmosis & reverse osmosis, colligative properties.

*Chromatography*

Principles of chromatography: liquid and gas chromatography; performance parameters: retention, resolution, basis of peak broadening, peak symmetry; chromatography equipment; modes of chromatography: ion exchange, gel filtration and affinity; brief overview on HPLC.

*Spectroscopy-I*

Theories of light (wave-particle duality); the electromagnetic spectrum; UV/visible absorption spectroscopy: physicochemical aspect, Beer-Lambert's law, Deviations of Beer Lambert's law; transitions, Applications of UV-visible spectroscopy in proteins and nucleic acids; Fluorescence and Chemiluminescence: theory, measurement, quenching, study of protein folding, application of fluorescence in cell biology.

*Spectroscopy-II*

Spectroscopic techniques using plane polarized light: polarized light, chirality of biomolecules, circular dichroism and linear dichroism.

Infrared Spectroscopy- Modes of molecular vibrations; Vibration of a diatomic molecule; Theory of Hooke's law; characteristic stretching frequencies of O-H, N-H, C-H, C-D, C=C, C=N, C=O, S-H functions; Factors affecting stretching frequencies (H-bonding, electronic factors, mass effects, bond multiplicity); Applications of FTIR for determination of secondary structure of proteins.



### *Hydrodynamics and Bio-calorimetry*

Viscosity: definition, measurement, effect of solutes, sedimentation and ultracentrifuge: physical basis, subcellular fractionation, sedimentation velocity and sedimentation equilibrium; enthalpy, entropy and free energy: relationship between these parameters, activation energy.

### **Reference Books**

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M. W.H. Freeman & Company (New York), ISBN: 10-14641-0962- 1.
2. Physical Biochemistry, Principles and Applications (2009) 2nd Ed., David Sheehan, Wiley, ISBN: 10- 04708-5603-3
3. Physical Biochemistry, (1982) 2nd Ed., David Friefelder, W. H. Freeman, ISBN: 10- 07167-1444-2
4. Biophysical Chemistry, Principles and Techniques (2016) 4th Ed., Upadhyay and Upadhyay, Himalaya Publishing House, ISBN: 10-93514-2227-5
5. Physical Biochemistry (2005) 2nd Ed., Van Holde, Prentice Hall, ISBN: 10-01304-6427-9
6. Fundamentals of Photochemistry, K. K. Rohatgi-Mukherjee (2014) 3<sup>rd</sup> Ed., New Age International Publishers, ISBN: 978-81-224-3432-3.
7. P. C. Rakshit, Physical Chemistry: Revised and Enlarges (2014), 7<sup>th</sup> Ed., Sarat Book Publishers.
8. Vogel's text book of quantitative chemical analysis (1989), Arthur Vogel, Longman Scientific & Technical Publishers.

**Course Code: CC-7**

**Course Title: Physical Biochemistry (Prac.)**

2 Credits

***List of Practicals***

1. Preparation and determination of pH of various buffers: phosphate, carbonate and acetate; effect of acid and alkali on the pH of above mentioned buffers.
2. Determination of isoelectric point of amino acids (Glycine, Glutamic acid and Histidine)
3. Verification of Beer's law using spectrophotometric and/ colorimetric technique.
4. Column chromatography (size exclusion, ion-exchange)

**Course Code: SEC-1**

**Course Title: Clinical Biochemistry**

2 credits

*Introduction*

Organization of clinical laboratory, Introduction to instrumentation and automation in clinical biochemistry laboratories safety regulations and first aid. General comments on specimen collection, types of specimen for biochemical analysis. Precision, accuracy, quality control, precautions and limitations.

- a. Collection of blood and storage.
- b. Separation and storage of serum.
- c. Analysis of Cell Morphology

*Evaluation of biochemical changes in diseases*

Biochemical mechanisms associated with the diseases of blood, liver, kidney, lungs and heart.

*Assessment of glucose metabolism in blood*

Clinical significance of variations in blood glucose. Diabetes mellitus. Estimation of blood glucose by glucose oxidase peroxidase method.

*Lipid profile*

Biochemical mechanisms associated with lipid disorder. Cholesterol (LDL, HDL, VLDL, apoproteins etc.), triglycerides, estimation of triglycerides & cholesterol (LDL & HDL).

*Liver function tests*

Estimation of bilirubin, SGPT & SGOT.

*Renal function tests and urine analysis*

Routine urine tests: pH, albumin. Quantitative determination of serum creatinine and urea.

*Tests for cardiovascular diseases*

Involvement of enzymes in diagnostics of heart disease including aspartate transaminase, isoenzymes of creatine kinase and lactate dehydrogenase and troponin. Assessment of hypertension by blood pressure measurement.

## **Reference Books**

1. Medical Laboratory Technology - a Procedure Manual for Routine Diagnostic Tests Vol. I (2010), Mukherjee, K.L., Tata Mc Graw–Hill Publishing Company Limited (New Delhi). ISBN:9780070076594 / ISBN:9780070076631.
2. Medical Laboratory Technology - a Procedure Manual for Routine Diagnostic Tests Vol. II (2010), Mukherjee, K.L., Tata Mc Graw – Hill Publishing Company Ltd. (New Delhi), ISBN: 9780070076648.
3. Medical Biochemistry (2005) 2nd ed., Baynes, J.W. And Dominiczak, M.H., Elsevier Mosby Ltd. (Philadelphia), ISBN: 0-7234-3341-0.
4. Experimental Biochemistry: A Student Companion (2005) Rao, B.S. and Deshpande, V., IK International Pvt. Ltd. (New Delhi), ISBN:81-88237-41-8.

**Course Code: SEC-1**

**Course Title: Bioinformatics and biostatistics**

2 credits

*Bioinformatics*

1. Basics of computer and operating systems.
2. Introduction to bioinformatics.
3. Computer networking.
4. Archiving and retrieval of informations : search engines, data basics, nucleic acid sequence, genomes, protein sequence & structure, bibliographic access of molecular biology data base, Entrez, sequence retrieval system (SRS), protein identification resource (PIR).
5. Comparing the amino acid sequence using BLAST P and demonstration of the significance of different score in BLAST P output.
6. Sequence allignments and phylogenetic trees.

*Biostatistics*

Primary and secondary data, frequency distribution, diagramatic representation, population and sample, statistical regularity, mean, median, mode, standard deviation, correlation co-efficient and their significances, some simple related problems on methods of sampling, hypothesis, test of significance. Some mathematical idea on Biostatistics.

**Reference Books**

1. Bioinformatics: Sequence and Genome Analysis (2001), 1st ed., Mount, D.W. Cold Spring Harbor Laborator Press (New York), ISBN: 0-87969-608-7.
2. Bioinformatics and Functional Genomics (2003), 1st ed., Pevsner, J., John Wiley & Sons, Inc. (New Jersey), ISBN: 0-47121004-8.
3. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (2005), 3rd ed., Baxevanis, A.D. and Ouellette, B.F., John Wiley & Sons, Inc. (New Jersey), ISBN: 0-47147878-
4. Bioinformatics – Principles and Applications (2008), 1st ed. Ghosh, Z. and Mallick, B., Oxford University Press (India), ISBN: 9780195692303.

**Course Code: GE-3**

**Course Title: Fundamentals of Cell Biology and Immunology (Theory)**

4 credits

*Membrane structure and function*

Composition of membranes, membrane lipids, membrane proteins, isolation and characterization. Integral, peripheral and lipid anchored protein. Transport across membranes, simple and facilitated diffusion, active transport.

*Endoplasmic reticulum and Golgi complex*

The two types of endoplasmic reticulum, rough and smooth. The Golgi complex. Role of Golgi in protein glycosylation and protein trafficking.

*Signalling mechanisms, messengers and receptors*

Chemical signals and cellular receptors. G-protein linked receptors, protein tyrosine kinase receptors, growth factor. Hormonal signalling: Epinephrine, thyroxine, steroid hormone receptor mediated signalling.

*Overview of the immune system*

Self-versus nonself. Humoral and cellular immunity. Innate and adaptive immunity. Cells and organs of immune system, primary and secondary lymphoid tissues and organs. Cellular and humoral responses, Innate and adaptive immunity.

**Reference Books**

1. The World of the Cell (2009), 7th ed., Becker W.M., Kleinsmith, L.J., Hardin. J., Bertoni, and G.P., Pearson Benjamin Cummings (CA), ISBN: 978-0-321-55418-5.
2. Prescott, Harley, Klein's Microbiology (2008) 7th Ed., Willey, J.M., Sherwood, L.M.,
3. Woolverton, C.J. Mc Graw Hill International Edition (New York) ISBN: 978-007- 126727.
4. Molecular Cell Biology (2013) 7th Ed., Lodish, H., Berk, A., Kaiser, C.A., Krieger, M.,
5. Bretscher, A., Ploegh, H., Amon, A. and Scott, M.P., Macmillan International Edition (New York), ISBN: 13: 978-1-4641-0981-2.

6. Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A., W.H Freeman and Company (New York), ISBN: 13: 978-0-7167-8590-3 / ISBN: 10:0-7617- 8590-0.
7. Immunology: A Short Course (2009) 6th ed., Coico, R and Sunshine, G., John Wiley&
8. Sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.

**Course Code: GE-3**

**Course Title: Fundamentals of Cell Biology and Immunology (Practical)**

4 credits

*List of Practicals*

1. Visualization of different types of cells by methylene blue.
2. Isolation of sub-organelles by differential centrifugation technique and their verification.
3. Blood grouping.
4. Antigen-antibody interaction by Ouchterlony double diffusion.
5. Preparation of Polytene chromosome from Chironomous/Drosophila sp.



## 4<sup>th</sup> Semester

**Course Code: CC-8**

**Course Title: Membrane Biology and Bioenergetics (Theo)**

4 credits

### *Introduction to biomembranes*

Composition of bio membranes - prokaryotic, eukaryotic and subcellular membranes. Membrane proteins. Monolayer, planer bilayer and liposomes as model membrane systems. Fluid Mosaic Model.

### *Membrane structures and dynamics*

Polymorphic structures of amphiphilic molecules in aqueous solutions - micelles and bilayers. CMC, critical packing parameter. Membrane asymmetry. Macro and micro domains in membranes. Membrane skeleton, lipid rafts, caveolae and tight junctions. RBC membrane architecture.

Lateral, transverse and rotational motion of lipids and proteins. Transition studies of lipid bilayer, transition temperature. Membrane fluidity, factors affecting membrane fluidity.

### *Membrane transport*

Thermodynamics of transport. Simple diffusion and facilitated diffusion. Passive transport - glucose transporter, anion transporter and porins. Primary active transporters - P type ATPases, V type ATPases, F type ATPases.  $\text{Ca}^{2+}$ -ATPases (Plasma membrane  $\text{Ca}^{2+}$ -ATPase + sarco/endoplasmic reticulum  $\text{Ca}^{2+}$ -ATPase). Secondary active transporters,  $\text{Na}^+$ -glucose symporter. ABC family of transporters - MDR, CFTR. Group translocation. Ion channels - voltage-gated ion channels ( $\text{Na}^+/\text{K}^+$  voltage-gated channel), ligand-gated ion channels (acetyl choline receptor), aquaporins, and bacteriorhodopsin. Ionophores.

### *Vesicular transport and membrane fusion*

Types of vesicle transport and their function - clathrin, COP I and COP II coated vesicles. Molecular mechanism of vesicular transport. Membrane fusion. Receptor mediated endocytosis of transferrin, envelope virus-host cell interaction.

### *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 and Nernst equation. Universal electron carriers.

### *Oxidative phosphorylation*

Mitochondria. Electron transport chain - its organization and function. Inhibitors of ETC and uncouplers. Peter Mitchell's chemiosmotic hypothesis. Proton motive force. Fo-F1ATP synthase, structure and mechanism of ATP synthesis. Metabolite transporters in mitochondria. Regulation of oxidative phosphorylation.

### **Reference Books**

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. Principles 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.

**Course Code: CC-8**

**Course Title: Membrane Biology and Bioenergetics (Prac.)**

2 Credits

*List of Practical*

1. Effect of lipid composition on the permeability of a lipid monolayer.
2. Determination of CMC of detergents.
3. Isolation of mitochondria from liver and assay of marker enzyme SDH.

**Course Code: CC-9**

**Course Title: Metabolism of Amino Acids and Nucleotides (Theo)**

4 credits

*Overview of amino acid metabolism*

Nitrogen cycle, incorporation of ammonia into biomolecules. Digestion and absorption of dietary proteins. Protein calorie malnutrition - Kwashiorkar and Marasmus. Nitrogen balance, transamination, role of pyridoxal phosphate, Krebs's bicycle, urea cycle.

*Catabolism of amino acids*

Catabolic pathways of individual amino acids. Glucogenic and ketogenic amino acids. Metabolism of one carbon units. Disorders of amino acids metabolism, phenylketonuria, alkaptonuria, maple syrup urine disease, methylmalonic acidemia (MMA), homocystinuria and Hartnup's disease.

*Biosynthesis of amino acids*

Overview of amino acid bio-synthesis: Alanine, Tyrosine, Tryptophan, Arginine & Proline.

*Precursor functions of amino acids*

Biosynthesis of creatine and creatinine, catecholamines (dopamine, epinephrine, norepinephrine) and neurotransmitters (serotonin, Gamma-Amino butyric acid). Porphyrin biosynthesis, catabolism and disorders of porphyrin metabolism.

*Biosynthesis of purine and pyrimidine nucleotides*

De novo synthesis of purine and pyrimidine nucleotides, regulation and salvage pathways.

*Deoxyribonucleotides and synthesis of nucleotide triphosphate*

Biosynthesis of deoxyribonucleotides and its regulation, conversion to triphosphates, biosynthesis of coenzyme nucleotides.

*Degradation of purine and pyrimidine nucleotides*

Digestion of nucleic acids, degradation of purine and pyrimidine nucleotides. Inhibitors of nucleotide metabolism. Disorders of purine and pyrimidine metabolism – Lesch-Nyhan syndrome, Gout.

*Integration of metabolism*

Integration of metabolic pathways (carbohydrate, lipid and amino acid metabolic pathways), tissue specific metabolism (brain, muscle, and liver), systems biology (introductory).

**Reference Books**

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 York), ISBN: 978-0-470-28173-4/BRV ISBN: 978-0-470-60152 5.

**Course Code: CC-9**

**Course Title: Metabolism of Amino Acids and Nucleotides (Prac.)**

2 credits

***List of Practical***

1. Assay of serum transaminases – SGOT and SGPT
2. Estimation of serum urea,
3. Estimation of serum uric acid
4. Estimation of serum creatinine

**Course Code: CC-10**

**Course Title: Basic Microbiology and Microbial Genetics (Theo)**

4 credits

*Introduction*

Spontaneous generation (abiogenesis), Biogenesis, Germ Theory of Disease, Koch's Postulates, Scope of Microbiology.

*Microorganisms in biological world*

Whittaker's Five-kingdom and three-kingdom concept of living organisms (General characteristics of those groups); General features of Eubacteria and Archaeobacteria.

*Bacterial Morphology, subcellular structures and Staining*

Morphology of bacteria, Slime layer, Mycelial morphology: Actinomycetes, Capsule, Cell wall, Ribosome, Cytoplasmic membrane (Fluid mosaic model of Singer - Nicholson); Cytoplasmic inclusion bodies - (inorganic, organic); Exospores & Cysts: types & structure; Endospore, Flagella, Pilus, Fimbriae (structure, composition and functions).

Definition of auxochrome; Chromophores; Acidic and Basic dyes; Classification of stains; Simple and differential staining: theories and mechanisms of gram staining; acid fast staining; endospore staining.

*Microbial Nutrition*

Nutritional types (definition and example) - Prototrophs, Autotrophs, Chemolithotrophs (ammonia, nitrite, sulfur, hydrogen, iron oxidizing bacteria);

Chemoorganotrophs, Effect of oxygen on growth - classification on the basis of oxygen requirement and tolerance.

*Bacterial Growth and its regulation*

Growth phases - Generation time. Bacterial growth curve, Batch culture. Continuous culture.

Synchronous culture (definition and brief description). Physical factors influencing growth such as temperature, pH, osmotic pressure, salt concentration.

Sterilization, disinfection, antiseptic, sanitizer, germicide (definition, application & examples); physical method of disinfection and sterilization - dry heat, moist heat, filtration, radiation (mode

of action, applications); Chemical control – dye solutions, alcohol, acid, alkali, halogen, heavy metal, phenol, phenol derivatives, formaldehyde, ethylene oxide, detergents (mode of action, applications).

Chemotherapeutic agents - sulphonamides, antibiotics, (definition types); mechanism of action and antimicrobial spectrum of penicillin, streptomycin, tetracycline, chloramphenicol, Nalidixic acid and metronidazole; drug resistance - phenomena and mechanism.

### *Microbial Genetics*

Extra chromosomal genetic elements, Bacterial Chromosome (Fundamental differences with eukaryotic chromosome). Mechanism of genetic exchange – transformation, transduction and conjugation. Gene mapping in bacteria. An introduction to virus with special reference to the structure, replication of T4 and  $\lambda$  phage, lytic and lysogenic cycles.

### **Reference Books**

1. General Microbiology (1999) 5th Edition: Stanier, RY., et al., Palgrave Macmillan, ISBN-10: 0333763645/ISBN-13: 978-0333763643
2. Microbiology 5th edition (2001): Pelczar. M., et al., Tata-McGraw Hill ISBN-10: 0074623206/ISBN-13: 978-0074623206
3. Principles of Microbiology 2nd edition(1997): Atlas, RM., McGraw-Hill, ISBN-10: 9339219872/ISBN-13: 978-9339219871
4. Fundamental principles of bacteriology (1999): Salle, AJ.,Tata- McGraw Hill, ISBN: 9781406707373/ 1406707376
5. Microbiology 6th Edition (2004): Prescott Lansing M. et al. McGraw Hill Higher Education ISBN-10: 0072951753/ ISBN-13: 978-0072951752



**Course Code: CC-10**

**Course Title: Basic Microbiology and Microbial Genetics (Prac.)**

2 credits

***List of Practical***

1. Microbiology Laboratory Practices and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter)
3. Preparation and sterilization of culture media for bacterial cultivation
4. Study of different shapes of bacteria, fungi, algae, protozoa using permanent slides/pictographs
5. Staining of bacteria using Gram stain
6. Isolation of pure cultures of bacteria by streaking method.

**Course Code: SEC-2**

**Course Title: Techniques in Biochemistry**

2 credits

*Basic Lab Practices and preparation of 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-Hasselbach equation, working of a pH meter. Preparation of a buffer of given pH and molarity.

*Spectrophotometric techniques*

Principle and instrumentation of UV-visible and fluorescence spectroscopy:

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

**Reference Books**

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.

**Course Code: SEC-2**

**Course Title: Protein Purification Techniques**

2 Credits

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

- a. Preparation of the sample.
- b. Ion-exchange chromatography.
- c. Gel filtration chromatography.
- d. Affinity chromatography.
- e. Electrophoresis (Native & SDS page), 2D-electrophoresis.

**Reference Books**

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.

**Course Code: GE-4**

**Course Title: Fundamentals of Genetic Engineering (Theo)**

4 credits

*Introduction to recombinant DNA technology*

Overview of recombinant DNA technology. Purification of plasmid and bacteriophage DNA. Enzymes used in manipulating DNA, Restriction Enzymes (blunt end, sticky end), ligase, polymerase (DNA polymerase & RNA polymerase), enzyme adapter. Concept of expression vectors and examples.

*Cloning vectors for prokaryotes and eukaryotes*

Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors based on E. coli plasmids, pBR322, pUC8. Cloning vectors based on M13 and  $\lambda$  bacteriophage.

*Construction, selection and identification of recombinants*

Ligation of DNA molecules. Transformation and electroporation, selection for transformed cells. Identification for recombinants, blue-white selection. Identification of recombinant phages. Direct selection, marker rescue. Gene libraries. Identification of a clone from gene library, colony and plaque hybridization probing.

*Polymerase chain reaction and DNA sequencing*

Fundamentals of polymerase chain reaction. Analysis of PCR products. DNA sequencing by Sanger's method and automated DNA sequencing.

*Expression of cloned genes*

Vectors for expression of foreign genes in E. coli, cassettes and gene fusions. Production of recombinant protein by eukaryotic cells. Challenges in producing recombinant protein in E. coli. Fusion Proteins – Brief Overview.

*Applications of genetic engineering in biotechnology*

Production of recombinant pharmaceuticals such as insulin. Gene therapy. Genetically modified plants such as herbicide resistant crops with special reference to BT cotton.

## Reference Books

1. Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York), ISBN:0-321-50781 / ISBN: 978-0-321-50781-5.
2. Gene Cloning and DNA Analysis (2010) 6th ed., Brown, T.A., Wiley-Blackwell Publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
3. Principles of Gene Manipulation and Genomics (2006) 7th ed., Primrose, S. B., and Twyman, R. M., Blackwell publishing (Oxford) ISBN: 13: 978-1-4051-3544-3.
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) 4th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC), ISBN: 978-1-55581-498-4 (HC).
5. Recombinant DNA: Genes and Genomes 3rd edition (2007): Watson, James D., et al. W.H. Freeman ISBN-10: 1429203129/ISBN-13: 978-1429203128.

**Course Code: GE-4**

**Course Title: Fundamentals of Genetic Engineering (Prac.)**

2 credits

***List of Practical***

1. Ultraviolet absorption spectrum of DNA and RNA.
2. Isolation of plasmid DNA and restriction digestion.
3. Agarose Gel electrophoresis
4. Amplification of a DNA fragment by PCR and gel electrophoresis
5. Determination of transformation efficiency.