Enclosure- III

Shree Manibhai Virani and Smt.Navalben Virani Science College, Rajkot (Autonomous)
Affiliated to Saurashtra University, Rajkot

Department of Biochemistry

B.Sc. BIOCHEMISTRY

B.Sc. BIOCHEMISTRY Syllabus
For Students Admitted From A.Y.2019-2020 and Onwards

SEMESTER -I

19UBCCC101	Core -1: Biophysical Chemistry	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

- Learn how physical laws govern biological processes.
- Acquire basic knowledge about how physical methods can be applied to understand biological processes.

Unit 1: Chemical Bonds **[12 Hrs]**

- Concepts of Atoms , Molecules and Electronegativity
- Chemical Bonds and their importance in structure of Biomolecules.
- Ionic Bonds, Covalent bond. Dipole moment and molecular structure.
- Weak chemical forces-hydrogen bond, inter and intramolecular hydrogen bonds, effects of hydrogen bonding, Van der Waals forces.
- Electrophiles and Nucleophiles.

Unit 2 Electrochemistry **[12 Hrs]**

- Oxidation and reduction
- Introduction to Electrochemistry :Electrochemical Cells and Galvanic Cells
- Nernst Equation : Derivation of Nernst equation , Application of Nernst equation
- Conductance of Electrolytic Solutions : conductivity, molar conductivity and Kohlrausch law
- Electrolytic Cells and Electrolysis

Unit 3: pH, Buffer and Physiological Buffers. **[12 Hrs]**

- Properties of Acid and Base.
- Shapes of titration curves of strong and weak acids and bases. Meaning of ka and pka values.
- Concept of pH and pOH, numerical problems of pH , methods to determine pH, pH meters- types of electrodes , principle and working of pH meter.
- Buffers, buffer capacity and factors affecting buffering capacity,

- Henderson – Hesselbalch equation, simple numerical problems involving application of this equation.
- Physiological Buffers: Types and importance.

Unit 4: Osmosis, Viscosity, Diffusion and Adsorption: [12 Hrs]

Basic principles, factors affecting, biological importance and applications of

- Osmosis,
- Viscosity ,
- Diffusion and
- Adsorption in life sciences.

Unit 5: Solutions [12 Hrs]

- Mole concept , Normal , Molar , Molal and Percent Solutions.
- Numerical problems. Stock, working solutions.
- Preparation of w/v, v/v and dilute solutions.
- Concepts of Density and specific gravity

Text Books:

1. Upadhyay, A., Upadhyay, K., & Nath, N. (2009). *Biophysical chemistry (principles and techniques*). Mumbai: Himalaya Pub. House. (Unit 2,3 and 4)
2. Satyanarayana, U., & Chakrapani, U. (2008). *Essentials of biochemistry*. Book and Allied, Kolkata, India,.(Unit 1 and 5)

Reference Books:

1. Van Holde, K. E., Johnson, W. C., & Ho, P. S. (2006). *Principles of physical biochemistry*. Prentice-Hall.
2. Wilson K. and Walker J. (2010) *Principles and Techniques of Biochemistry and Molecular Biology* 7th Edition, Cambridge: Cambridge University Press.
3. Cooper, T. G. (2010). *The tools of biochemistry*. New York: Wiley.

19UBCCC102	Core -2: Biomolecules	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

1. Learn the basic structures, functions and biological importance of water.
2. Understand structure, properties and functions of different biomolecules - carbohydrates, lipids, amino acids, vitamins and nucleic acids..

Unit 1: The foundations of biochemistry and Water [12 Hrs]

- Cellular and chemical foundations of life
- Physical and Chemical properties of water
- Weak interactions in aqueous systems
- Importance of water in living organisms

Unit 2: Carbohydrates and glycobiology [12 Hrs]

- Monosaccharides - structure , function and properties ,

- Formation of disaccharides, reducing and nonreducing disaccharides.
- Polysaccharides –types, structure and function
- Proteoglycans, glycoproteins and glycolipids-–types, structure and function

Unit 3: Lipids **[12 Hrs]**

- Building blocks of lipids - fatty acids, glycerol, ceramide.
- Classification of lipids
- Storage lipids - triacylglycerol and waxes.
- Structural lipids in membranes – glycerophospholipids, galactolipids and sulpholipids, sphingolipids
- Sterols, structure, distribution and role of membrane lipids.

Unit 4: Amino acids and Porphyrins **[12 Hrs]**

- Structure and classification of amino acids.
- Physical, chemical and optical properties of amino acids
- Biologically important amino acids (standard and non standard)
- Porphyrins: Porphyrin nucleus and classification of porphyrins. Important metalloporphyrins occurring in nature. Detection of porphyrins spectrophotometrically and by fluorescence.
- Bile pigments- chemical nature and their physiological significance.

Unit 5: Nucleic acids **[12 Hrs]**

- Experimental evidences of Genetic Material
- Building Blocks of Nucleic Acids
- Nucleic acid structure – Watson-Crick model of DNA, Different forms of DNA
- Structure of major species of RNA - mRNA, tRNA and rRNA.
- Nucleic acid chemistry- UV absorption, effect of acid and alkali on DNA.

Text Books:

1. Conn Erice, E. and Stumpf Paul, K. (2007).*Outlines of Biochemistry*, [5th Edition]. John Wiley & Sons, New Delhi.(Unit 1 and 2)
2. Jain, J. L. Sunjay Jain and Nitin Jain (2004). *Fundamentals of biochemistry*. S. Chand Publishing, New Delhi.(Unit 3,4 and 5)

Reference Books:

1. Nelson, D. L., & Cox, M. M. (2013). *Lehninger Principles of Biochemistry*. [6th edition] Freeman and Company, New York.
2. Berg, J. M., Tymoczko, J. L., Gatto G.J. & Stryer, L., (2015) *Biochemistry*, [8th Revised edition] W H Freeman, New York.
3. Devlin, T. M. (Ed.). (2010). *Textbook of biochemistry: with clinical correlations*. 7th Edition, John Wiley & Sons, New York.

19UBCCC103	Core Practical 1: Biochemistry Practicals- I	6 Hrs/wk	3 Credits

Objectives:

To enable students to

- The ability to apply lecture concepts in a laboratory setting.
- To obtain basic laboratory skills such as microscopy, spectrophotometry, measuring, etc. and understands the principles and concepts behind basic techniques used by cell biologists.
- Perform chemical tests to determine the presence/absence of carbohydrates, proteins and lipids

List of Practicals:

1. Safety measures and introduction to basic instruments used in biochemistry laboratory
2. Importance of calibration and cleaning of instruments and glasswares
3. Principle and use of pH meter
4. Checking the pH of different biological and non biological samples (Fruit Juices, Soft drinks etc.)
5. Preparation of different buffer solutions.
6. Numerical problems for the preparation of Normal and Molar solutions.
7. Preparation of Normal solutions and Molar Solutions.
8. Numerical problems for the preparation of percent solution and dilutions.
9. Preparation of percent solutions and dilutions.
10. Introduction to principle and working of colorimeter
11. Qualitative tests for carbohydrates.
12. Qualitative tests for lipids.
13. Qualitative tests for amino acids.
14. Estimation of reducing sugar by DNSA method
15. Estimation of Chlorophyll.
16. Estimation of amino acid by Ninhydrin method.

Reference Books:

1. Sadasivam, S. and Manickam, A. 2010. *Biochemical Methods*. [Third Edition]. New Age International (P) Ltd., New Delhi.

2. Jayaraman, J. 2008. *Laboratory Manual in Biochemistry*. [First Edition Reprint]. New Age International (P) Ltd., New Delhi.

Semester II

19UBCCC201	Core -3: Cell Biology	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

- Understand the relationship between organization and functions of cell and subcellular organelles.
- Identify the roles of cell division in reproduction, growth, and repair.

Unit 1: Introduction to Cell, Cell morphology and Cell theories [12 Hrs]

- Definition of Cell, History of cell biology and levels of organizations in biology
- Structure and Characteristics of Prokaryotic cell (archaea and eubacteria)
- Structural and functional diversity in Eukaryotic cell
- Comparison of Prokaryotic and Eukaryotic cell

Unit 2: Tools and Techniques [12 Hrs]

- Principle ,optical arrangements and applications of : Light microscopy.
- Phase contrast microscopy and fluorescence microscopy: Basic Principles and Applications
- Overview of Electron Microscopy: SEM and TEM.
- Principle and technique for Subcellular fractionation**.**

Unit 3: Cell Organelles [12 Hrs]

- Structure, composition and function of Plasma membrane and Nucleus
- Membranous Organelles: ER structure. Golgi complex and lysosomes.
- Energy Harnessing Organelles: Mitochondria and chloroplasts
- Maternal inheritance of mitochondria and endosymbiosis hypothesis regarding origin of mitochondria.
- Microbodies- Peroxisomes and glyoxysomes

Unit 4: Cell wall and Components of Cytoskeleton [12 Hrs]

- Structure , Composition and functions of Prokaryotic cell wall
- Structure , Compositions and functions of Plant cell wall
- Structure and organization composition and functions of microtubules, microfilaments and intermediate filaments.
- Intracellular localization of cytoskeleton components
- Assembly, organization and movement of cilia and flagella.

Unit 5: Cell cycle, cell death and cell renewal [12 Hrs]

- Overview of Eukaryotic cell cycle and Checkpoints
- Process of mitotic cell division and its physiological significance.
- Events in meiotic cell division and its significance.
- Apoptosis and necrosis - brief outline.

Text Books:

1. Robertis De (2011). *Cell and Molecular Biology* / 8th Edn. Wolter Kluwer (Unit 2 and 5)
2. Verma P.S. and Agarwal V.K. (2004). *Cell Biology, Genetics, Molecular Biology, Evolution & Ecology* , S Chand Publishing, New Delhi.(Unit 1,3 and 4)

Reference Books:

1. Cooper, G.M. and Hausman, R.E., (2009) .*The Cell: A Molecular Approach* (5th ed.), ASM Press & Sunderland (Washington DC), Sinauer AssoCIEtes, MA,

2. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell. (2012) *Molecular Cell Biology* 7th ed., J., W.H. Freeman & Company ,New York,
3. Alberts, B., Johnson,A., Lewis, J., and Enlarge, M. (2008) *Molecular Biology of the Cell*, 5th ed., , Garland Science (Princeton).

19UBCCC202	Core-4:Human Physiology-I	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

- Understand the anatomy of major organs
- Major organ correlation to the physiological processes within the organ systems of the human body.

Unit 1: Homeostasis and Blood **[12 Hrs]**

- Intracellular, extracellular and interstitial fluid.
- Homeostasis, control system and their components.
- Components of blood and their functions
- Overview of erythropoesis and leucopoesis
- Blood grouping and clotting - ABO and rhesus (Rh) system, Blood clotting factors, Intrinsic and extrinsic pathways for blood coagulation.
- Hematological disorders – Types of anemia, polycythemia, leukemia, heamophilia, thrombocytopenia, etc.

Unit 2: Cardiovascular physiology **[12 Hrs]**

- Anatomy and Physiology of the cardiac muscle.
- Anatomy of heart and blood vessels.
- Mechanism of Cardiac cycle, heart sounds, ventricular volumes and the ECG.
- Disorders : Hypertension, congestive heart disease, atherosclerosis and myocardial infarction.

Unit 3: Respiratory system **[12 Hrs]**

- Components and functions of pulmonary system.
- Principles and mechanism of exchange and transport of respiratory gases.
- Role of Hb in transport of oxygen and dissociation curve
- Mechanism and Control of respiration, respiratory volumes,
- Respiratory disorders: Hypoxia, hypercapnia, pulmonary distress, emphesema, asthma and pneumonia.

Unit 4: Renal physiology **[12 Hrs]**

- Anatomy and functions of the kidney and excretory system, Nephron as functional unit of kidney.
- Physiology of glomerular filtration and GFR.
- Mechanism of urine formation (Ultra filtration, selective reabsorption and tubular secretion) and excretion.

- Regulation of electrolytes and water balance.
- Renal disorders and treatment: Glomerular nephritis, renal failure, dialysis and diuretics.

Unit 5: Gastrointestinal physiology **[12 Hrs]**

- Brief anatomy of digestive system. .
- Chemical composition and functions of digestive juices, Overview and control of secretion of digestive juices.
- Process of digestion and absorption of carbohydrates, lipids and proteins.
- Absorption of water, vitamins and minerals from gastrointestinal tract.
- Disorders related to digestive system: Hyperacidity, gastric ulcers, pancreatitis, gall stones, diarrhoea and vomiting.

Text Books:

1. Chaudhuri, S. K. (2011). *Concise medical physiology*. New Central Book Agency; 6th Revised edition .(Unit 1-5)

2. Sembulingam, K., & Sembulingam, P. (2012). *Essentials of medical physiology*. JP Medical Ltd.(Unit 1-5)

Reference Books:

1. Hall, J. E. (2015). Guyton and Hall *Textbook of medical physiology*. Elsevier Health Sciences.
2. Waugh, A., & Grant, A. (2014). *Ross & Wilson anatomy and physiology in health and illness*. Elsevier Health Sciences. Churchill Livingstone; 12 edition
3. Tortora, G. J., & Derrickson, B. H. (2014). *Principles of anatomy and physiology*. John Wiley & Sons.

19UBCCC203	Core-5: Human Physiology –II & Endocrinology	4 Hrs/wk	4 Credits

Objectives:

To enable students to

- Understand the physiological mechanisms controlling the reproductive processes in humans.
- Understand the role of Nervous and Endocrine systems in homeostasis.
- Learn about the chemistry, physiological roles and control of secretion of
- various classes of hormones.

Unit 1: Neurochemistry, Neurophysiology and Musculoskeletal system

[12 Hrs]

- Organization of the nervous system.
- Structure of a typical neuron.
- Different types of neuronal and glial cells and their functions.
- Nerve impulse and neurotransmission.

- Synapses: chemical and electrical synapses.
- Neurotransmitter: properties, different types, action and inactivation.
- Physiology of muscle contraction in striated and non-striated muscle.

Unit 2: Reproductive Physiology [12 Hrs]

- Sex determination and differentiation.
- Development of female and male genital tracts.
- Spermatogenesis, capacitation and transport of sperm, blood testis barrier.
- Ovarian function and its control.
- Uterine changes, fertilization and implantation.
- Placenta as a feto- maternal unit, gestation and parturition.

Unit 3: Introduction to Endocrinology [12 Hrs]

- Chemical signaling - endocrine, paracrine, autocrine, intracrine and neuroendocrine mechanisms.
- Chemical classification of hormones,
- Properties and functions of hormones and their regulation.
- Hormone receptors - extracellular and intracellular.
- G proteins, G protein coupled receptors, , second messengers - cAMP, cGMP, IP3,DAG, Ca2+.
- Hormone therapy and its types.

Unit 4: Hypothalamic and Pituitary Hormones, Thyroid gland, Hormones regulating Ca^{2+} homeostasis [12 Hrs]

- Hypothalamic - pituitary and target gland axis. Feedback regulation cycle.
- Physiological and biochemical actions of hypothalamic hormones, pituitary hormones disorders -gigantism, acromegaly, dwarfs, pigmies and diabetes insipidus.
- Biosynthesis of thyroid hormone and its regulation; its physiological and biochemical action. Goiter, Graves disease, cretinism, myxedema, Hashimato's disease.
- PTH, Vitamin D and calcitonin. Mechanism of Ca2+ regulation and pathways involving bone, skin, liver, gut and kidneys, rickets, osteomalacia, osteoporosis.

Unit 5: Pancreatic and GI tract hormones, Adrenals and Reproductive hormones [12 Hrs]

- **Pancreatic Hormones:** Insulin and glucagon
- Physiological and biochemical action. Pathophysiology - diabetes type I and type II.
- GIT and Other Hormones: Adipolectin, gastrin, secretin, CCK, GIP ,leptin and ghrelin.
- **Adrenal cortical and Medullary Hormones,** Aldosterone- Renin angiotensin system, Fight or flight response. Addison's disease, Conn's syndrome, Cushing`s syndrome.
- Male and female sex hormones.
- Interplay of hormones during reproductive cycle, pregnancy, parturition and lactation. Hormone based contraception.

Text Books:

1. Chaudhuri, S. K. (2011). *Concise medical physiology*. New Central Book Agency; 6th Revised edition .(Unit 1-5)
2. Sembulingam, K., & Sembulingam, P. (2012). *Essentials of medical physiology*. JP Medical Ltd.(Unit 1-5)

Reference Books:

1. Hall, J. E. (2015). *Guyton and Hall Textbook of medical physiology*. Elsevier Health Sciences.
2. Waugh, A., & Grant, A. (2014). *Ross & Wilson anatomy and physiology in health and illness*. Elsevier Health Sciences. Churchill Livingstone; 12 edition
3. Tortora, G. J., & Derrickson, B. H. (2014). *Principles of anatomy and physiology*. John Wiley & Sons.

19UBCCC204	Core Practical 2: Biochemistry Practicals- II	6 Hrs/wk	3 Credits

Objectives:

To enable students to

- The ability to apply lecture concepts in a laboratory setting.
- To obtain basic laboratory skills such as microscopy, measuring, etc. and understand the principles and concepts behind basic techniques used by cell biologists.
- Measure physiological responses and performance using equipments and carry out analytical procedures
- Observe phenomena, record and analyze data, and infer from data.

List of Practicals:

1. Staining and Visualization of plant cell.
2. Staining and Visualization of animal cell.
3. Identification of different stages of mitosis in onion root tip.
4. Identification of different stages of meiosis in grasshopper testis.
5. Micrographs of different cell components (dry lab).
6. Introduction to Hematology
7. Blood Grouping.
8. Haemoglobin Estimation.
9. Understanding of Nuebauer chamber.
10. Total RBC Count.
11. Total WBC count.
12. Differential Count.
13. Determination of Packed cell volume
14. Determination of Red Cell Indices.
15. Bleeding Time and Clotting Time.
16. Physical and Chemical Analysis of Urine.
17. hCG based pregnancy test.

Reference Books:

1. Mukherjee K. L. Medical Laboratory Technology (Volume I,II & III): (2010) Procedure Manual for Routine Diagnostic Tests 2 edition McGraw Hill Education India Private Limited
2. Godkar P. B., Godkar D. P. (2014) Textbook of Medical Laboratory Technology .Vol 1 & 2 Bhalani Publishing House; 3rd edition

SEMESTER -III

19UBCCC301	Core 6:Analytical Biochemistry	4 hrs/wk	4 Credits

Objectives:
To enable the students to

- Understand the principles of various biophysical techniques and their working.
- Apply this knowledge for characterization, separation, identification and purification of different biomolecules.

Unit 1: Spectroscopic techniques [12 Hrs]

- Electromagnetic radiation and spectra. Quantitative aspects of light absorption; Beer-Lamberts laws of light absorption with their limitations. Extinction coefficients.
- Instrumentation, principles, components and working of single and double beam colorimeter and spectrophotometer.
- Advantages of double beam instruments. Applications of UV-Visible spectroscopy.

Unit 2: Hydrodynamic techniques [12 Hrs]

- Sedimentation- the concepts of Centrifugal force (F) and Relative centrifugal force (RCF).
- Different types of rotors and centrifuges.
- Preparative and analytical centrifugation- instrumentation, techniques, and their applications.
- Differential centrifugation and its applications in isolation of cell organelles. Principle of density gradient centrifugation, materials used to prepare density gradient and applications of density gradient centrifugation.

Unit 3: Radio isotopic techniques [12 Hrs]

- Radioactive decay by emission of alpha, beta and gamma radiations with suitable examples. Half life of radio isotopes. Types of radioisotopes commonly used in biochemistry, units of radioactivity.
- Techniques for measurement of radioactivity (gas ionization and liquid scintillation counting). Overview of GM counter, Liquid Scintillation counter and gamma counters.
- Biological applications of radioisotopes. Biological hazards of radiation and safety measures in handling radioisotopes.

Unit 4: Chromatography [12 Hrs]

General principles, materials, methods and applications of the following techniques:

- Paper and thin-layer chromatography techniques.
- Ion exchange chromatography.
- Molecular sieve chromatography.
- Affinity chromatography
- Gas-Liquid chromatography (GLC)
- High performance liquid chromatography (HPLC)

Unit 5: Electrophoresis [12 Hrs]

- Basic principles of electrophoresis and factors affecting electrophoretic mobility.
- Principle, materials, apparatus used and applications of Agarose and Polyacrylamide gel electrophoresis (PAGE).
- Principle and applications of SDS PAGE, Native v/s SDS PAGE, Isoelectric focusing and 2D Gel electrophoresis

Text Books

1. Upadhyay, A., Upadhyay, K., & Nath, N. (2009). *Biophysical chemistry (principles and techniques*). Mumbai: Himalaya Pub. House. (Unit 1 -5)
2. Wilson K. and Walker J. (2010) *Principles and Techniques of Biochemistry and Molecular Biology* 7th Edition, Cambridge: Cambridge University Press. (Unit 1 -5)

Reference Books

1.Conn Erice, E. and Stumpf Paul, K. (2007).*Outlines of Biochemistry*, [5th Edition]. John Wiley & Sons, New Delhi.
2.Freifelder, D. (1986). *Physical biochemistry: Applications to biochemistry and molecular biology*. San Francisco: W.H. Freeman.
3.Van Holde, K. E., Johnson, W. C., & Ho, P. S. (2006). *Principles of physical biochemistry*. Prentice-Hall.

19UBCCC302	Core 7: Protein Biochemistry	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

- Describe/recognize amino acid structures; describe their physical and chemical properties, and predict how their ionic charges change with pH.
- Define primary, secondary, tertiary and quaternary structure in proteins and identify the types of interactions important in each case

Unit 1. Introduction to peptides and proteins [12 Hrs]

- Biologically important peptides - hormones, antibiotics and growth factors.
- Physical and chemical Properties of protein
- Chemical classification: Multimeric proteins, conjugated proteins and metallo proteins and their properties.
- Nutritional Classification of protein
- Functional classification and diverse biological functions of proteins.

Unit 2. Protein structure [12 Hrs]

- Nature of stabilizing bonds - covalent and non covalent.
- The peptide bond - bond lengths and configuration.
- Primary, Secondary, Tertiary and quaternary structures.
- Overview on Protein folding and protein folding disorders.
- Structures and functions of globular (myoglobin/ haemoglobin) and fibrous proteins(collagen/ keratin).

Unit 3. Peptide mapping and protein sequencing [12 Hrs]

- N-terminal and C-terminal amino acid analysis.
- Sequencing techniques – Edman's degradation, Sanger's method and Automation.
- Generation of overlap peptides using different enzymes and chemical reagents.
- Disulfide bonds and their location.

Unit 4. Extraction and Separation techniques of proteins [12 Hrs]

- Sources, availability and abundance of different proteins for isolation and separation, Solubilization of proteins from their cellular and extracellular locations.
- Application of simple homogenization methods: Glass Teflon homogenizer, Grinding, Ultrasonication, French press, Osmotic lysis, and Enzymatic methods.
- Ammonium sulphate fractionation, solvent fractionation, and dialysis.
- Methods for protein purification: Ion-exchange chromatography, Molecular sieve chromatography and Affinity chromatography.

Unit 5. Analytical techniques and clinical aspects of proteins [12 Hrs]

- Determination of purity, molecular weight, extinction coefficient and sedimentation coefficient, IEF, SDS-PAGE and 2-D electrophoresis.
- Molecular structure and different types of immunoglobulins
- Prions and Prion diseases.
- Haemoglobinopathies- sickle cell anemia and overview of types of thalessemia.
- Collagen and elastin related diseases.

Text Books:

1. Satyanarayan, U., & Chakrapani, U. (2013). *Textbook of Biochemistry* .4 edition (Unit 1,2 and 3)
2. Upadhyay, A. (2009). *Biophysical chemistry*. Himalaya Publication.(Unit 4 and 5)

Reference Books:

1. Wilson K. and Walker J. (2010) *Principles and Techniques of Biochemistry and Molecular Biology* 7th Edition
2. Nelson, D. L., & Cox, M. M. (2013). *Lehninger principles of biochemistry*. 6th ed. Freeman and Company (New York).
3. Garrett, R. H., & Grisham, C. M. (2010). *Biochemistry*, Brooks/Cole; International edition of 4th revised edition

19UBCCC303	Core -8: Enzymology	4 Hrs/wk	4 Credits

Objectives:
To enable students to

- Know fundamentals of enzyme structure, function, mechanism and kinetics of soluble and immobilized enzymes.
- Understand regulation, current applications and future potential of enzymes.

Unit 1: Introduction to enzymes Features of enzyme catalysis [12 Hrs]

- Nature and properties of enzymes - protein and non-protein (ribozyme).
- Cofactor and prosthetic group, apoenzyme, holoenzyme.
- IUBMB classification of enzymes.
- Factors affecting the rate of chemical reactions, collision theory, activation energy and transition state theory.
- Fischer's lock and key hypothesis and Koshland's induced fit hypothesis.
- Different methods of enzyme assay.

Unit 2: Enzyme kinetics [12 Hrs]

- 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.
- Determination and significance of Km , Vmax, Kcat and turnover number.
- Effect of pH, temperature and metal ions on the activity of enzyme.
- Types of bi bi reactions (sequential – ordered and random, ping pong reactions).

Unit 3: Role of coenzymes and Mechanism of action of enzymes [12 Hrs]

- Role of coenzymes in enzyme reactions:TPP, FAD, NAD, pyridoxal phosphate, biotin, coenzyme A, tetrahydrofolate, lipoic acid.
- Overview of mechanism of enzyme action - proximity and orientation, strain and distortion, acid base and covalent catalysis.
- Metal activated enzymes and metalloenzymes.
- Transition state analogues –types and applications.

Unit 4: Enzyme inhibition and Regulation of enzyme activity [12 Hrs]

- Reversible (competitive, uncompetitive, non-competitive, mixed and substrate) and irreversible inhibition.
- Control of activities of single enzymes (end product inhibition) and metabolic pathways, Feedback inhibition
- Introduction to allosteric enzyme and its regulation- Aspartate Transcarbomylase.
- Regulation by covalent modification- Glycogen Phosphorylase and Glycogen Synthase
- Zymogens- Digestive enzymes, isoenzymes – LDH and Hexokinase.
- Multienzyme complex as regulatory enzymes- Pyruvate Dehydrogenase complex.

Unit 5: Applications of enzymes [12 Hrs]

- Clinical and diagnostics application of enzymes, enzyme applications in therapeutics, enzyme immunoassay (HRPO).
- Application of enzymes in industries- Food, Dairy, Detergent, Paper, Textile and Leather Industry
- Different methods of enzyme immobilization and their applications.

Text Books

1. Nicholas C.Price and Lewis Stewens *Fundamentals of Enzymology* (1999) 3rd ed., Oxford University Press Inc. (New York),(Unit 4 and 5)

2. Jain, J. L. Sunjay Jain and Nitin Jain (2004). *Fundamentals of biochemistry*. S. Chand Publishing, New Delhi. (Unit 1,2 and 3)

Reference Books

1.Nelson, D.L. and Cox, M.M..Lehninger: *Principles of Biochemistry* (2013) 6th ed., W.H.Freeman and Company (New York).
2. Donald, Voet. and Judith G.Voet., *Biochemistry* (2011) 4th ed., John Wiley & Sons Asia Pvt.Ltd. (New Jersey).
3. Campbell, N. A., & Reece, J. B. (2016). *Campbell biology*. Boston: Pearson.
4. Dixon, M., & Webb, E. C. (1964). *Enzymes*. Academic Press, New York.

19UBCCC304	Core Practical 3: Biochemistry Practicals- III	6 Hrs/wk	3 Credits

Objectives:

To enable students to

- The ability to apply lecture concepts in a laboratory setting.
- Carry out an enzyme experiment at different temperatures, pH values, enzyme concentrations and substrate concentrations.
- Explain and apply the basic principles of various biochemical techniques.

List of Practicals:

1. Qualitative analysis of proteins
2. Estimation of proteins by Biuret method.
3. Estimation of proteins by Lowry method.
4. Isolation of casein from milk.
5. Isoelectric pH of casein.
6. Molecular weight and subunit determination of proteins by native PAGE and SDS-PAGE. (Dry lab)
7. An introduction to practicals in enzymology.
8. Assay of enzyme Acid Phosphatase.
9. Enzyme curve of Acid Phosphatase.
10. Substrate curve of Acid Phosphatase.
11. pH curve of Acid Phosphatase
12. Temperature Curve of Acid Phosphatase.
13. Determination of Specific activity of enzyme.
14. Determination of absorption spectrum and absorption maxima of given compound.
15. Verification of Beer's Law of light absorption using colored solutions.
16. Introduction to principle and working of centrifuge.
17. Separation of amino acids using paper chromatography. Determination of Rf values and identification of amino acids from mixtures.
18. Separation of lipids by thin layer chromatography.
19. Separation of compounds using column chromatography.
20. Separation of Dyes using chalk chromatography.
21. Agarose Gel electrophoresis of DNA.

Reference Books:

1. Wilson, K., & Walker, J. M. (2000) *Principles and techniques of practical biochemistry*. Cambridge: Cambridge University Press.
2. J. *Jayaraman* (2011) *Laboratory Manual in* Biochemistry *New Age International Publishers, New Delhi.*
3. Thimmaiah S.R. (2004) *Standard Methods of Biochemical* Analysis. Kalyani Publishers, New Delhi.

SEMESTER -IV

19UBCCC401	Core -9: Metabolism	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

- Elucidate various metabolic pathways and their significance
- Integrate different metabolic pathways and understand the cause of various metabolic diseases.

Unit 1: Basic design and metabolism of carbohydrate [12 Hrs]

- Metabolic pathways, catabolism and anabolism.
- Glycolysis - reactions of glycolysis and control of glycolysis.
- Synthesis of glucose from various non-carbohydrate sources,(Gluconeogenesis)
- Pentose phosphate pathway and its importance.
- Glycogenesis and glycogenolysis, Regulation of glycogen metabolism.

Unit 2: Citric acid cycle and Glyoxalate pathway [12 Hrs]

- Metabolic fates of pyruvate and acetyl CoA
- TCA (citric acid cycle) as a central metabolic pathway and its importance.
- Subcellular localization of TCA cycle and Reactions of citric acid cycle.
- anaplerotic reactions and amphibolic role of TCA cycle.
- Regulation of citric acid cycle.
- Glyoxalate pathway and its significance in plants.

Unit 3: Metabolism of lipids [12 Hrs]

- Synthesis and breakdown of triglycerides, Significance of fats (TAG) as major energy storage form of fuel in human body.
- Fatty acid transport to mitochondria, Activation and β oxidation of fatty acids, overview of oxidation of unsaturated and odd numbered fatty acids
- Fatty acid synthase complex as a multienzyme complex and synthesis of fatty acids. Comparison of fatty acid synthesis and fatty acid oxidation
- Ketone bodies metabolism, Causes for ketosis and ketoacidosis.
- Important steps in synthesis of cholesterol and its regulation. Overview of different types of cholesterol lowering drugs.
- Different types of lipoproteins and their role in transport of lipids.

Unit 4: Overview of amino acid metabolism [12 Hrs]

- Importance and biological functions of different amino acids, peptides and proteins. Why proteins are not preferred as an energy source in human body? Glucogenic and ketogenic amino acids. Entry points of different amino acids in TCA cycle.

- Oxidative deamination and transamination reactions in amino acid catabolism. Amino acid decarboxylation reaction and synthesis of different biologically important amines.
- Ammonotelic,Uricotelic and ureotilic organisms .Reactions of Urea cycle. Link between urea cycle and TCA cycle.
- Role and pathway of conversion of tyrosine in synthesis of various biologically important pigments, hormones and neurotransmitters.
- Essential v/s non essential amino acids. Overview of biosynthesis of non-essential amino acids.
- Disorders of amino acids metabolism, phenylketonuria, albinism, alkaptonuria, maple syrup urine disease.

Unit 5: Metabolism of nucleic acids [12 Hrs]

- Chemical Structures of purine and pyrimidine bases, nucleoside and nucleotides.
- Salvage and denovo synthesis of Purine and pyrimidine nucleotides
- Conversion of ribonucleotides to deoxyribonucleotides and to triphosphates,
- Degradation of nucleic acids, purine and pyrimidine nucleotides.
- Inhibitors of nucleotide metabolism.
- Disorders of purine and pyrimidine metabolism – Lesch-Nyhan syndrome, Gout, SCID, adenosine deaminase deficiency.

Text Books

1. . Nelson, D. L., Cox, M. M., & Lehninger, A. L. (2013) 6th ed., *Lehninger principles of biochemistry* Freeman and Company (New York), (Unit 1-5)
2. Deb, A. C. (2006). *Fundamentals of Biochemistry*. Calcutta, India: New Central Book Agency. (Unit 1-5)

Reference books

1 Campbell, N. A., & Reece, J. B. (2016). *Campbell biology: Concepts & connections*. Boston: Pearson
2. Devlin, T. M. (2011) *Textbook of Biochemistry with Clinical Correlations*. 7th ed., John Wiley & Sons, Inc. (New Jersey).
3. Berg, J. M., Tymoczko, J. L., & Stryer, L (2012),*Biochemistry* , 7th ed., W.H. Freeman and Company (New York).
4. Garrett, R. H., & Grisham, C. M. (2013). *Biochemistry Belmont*, CA: Brooks/Cole, Cengage Learning.

19UBCCC402	Core -10: Membrane Biology and Bioenergetics	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

- Know the structure and composition of biological membranes
- Understand functions of biomembranes and bioenergetics .

Unit 1: Introduction to biomembranes [12 Hrs]

- Composition of biomembranes - prokaryotic, eukaryotic, neuronal and subcellular membranes.

- Fluid mosaic model with experimental proof. Monolayer, planer bilayer and liposomes as model membrane systems.
- Polymorphic structures of amphiphilic molecules in aqueous solutions - micelles and bilayers.Membrane asymmetry-lateral diffusion and flip flop movement of phospholipids and proteins.FRAP experiment
- Membrane fluidity, factors affecting membrane fluidity.

Unit 2: Membrane transport [12 Hrs]

- Thermodynamics of transport. Simple diffusion and facilitated diffusion.
- Passive transport -glucose transporter, anion transporter and aquaporins**.**
- Primary active transport and Secondary active transport
- Ion channels - voltage-gated ion channels (Na+/K+ voltage-gated channel),
- Ligand-gated ion channels (acetyl choline receptor),
- Ionophores – mobile carriers and channel formers with suitable examples.

Unit 3: Vesicular transport and membrane fusion [12 Hrs]

- Exocytosis
- Endocytosis: Pinocytosis and Phgocytosis.
- Receptor mediated endocytosis of LDL
- Liposome mediated drug delivery systems and its applications

Unit 4: Introduction to bioenergetics [12 Hrs]

- Laws of thermodynamics., Concept of Gibb's free energy –Spontaneous and Non spontaneous reactions.
- Equilibrium constant, coupled reactions, ATP cycle, Phosphorylation potential, phosphoryl group transfers.
- Chemical basis of high standard energy of hydrolysis of ATP, other high energy phosphorylated compounds and thioesters.
- Biochemical equation-oxidation reduction reaction-redox potential and its role in biological reaction.
- Relationship between reduction potential and Gibb's free energy and its equilibrium constant

Unit 5: Mitochondrial, Electron transport chain & Oxidative phosphorylation [12 Hrs]

- Mitochondria, Electron transport chain - its organization and function.
- Basic Introduction to Peter Mitchell's chemiosmotic hypothesis. Proton motive force.
- Fo F1-ATPase : structure and mechanism of ATP synthesis.
- Regulation of oxidative phosphorylation.
- Glycerol phosphate and malate aspartate shuttle systems for transport of cytosolic NADH.
- ADP to Oxygen ratio.
- Inhibitors of ETC and uncouplers.

Text Books

1. Campbell, N. A., & Reece, J. B. (2016). *Campbell biology: Concepts & connections.* Boston: Pearson (Unit 4 and 5)

2. Deb, A. C. (2006). *Fundamentals of biochemistry*. Calcutta, India: New Central Book Agency. (Unit 1,2 and 3)

Reference books

1. Nelson, D. L., Cox, M. M., & Lehninger, A. L. (2013) 6th ed., *Lehninger principles of biochemistry* Freeman and Company (New York).
2. Berg, J. M., Tymoczko, J. L., & Stryer, L (2012) ,*Biochemistry* , 7th ed., W.H. Freeman and Company (New York).
3. Garrett, R. H., & Grisham, C. M. (2013). *Biochemistry*. Belmont, CA: Brooks/Cole, Cengage Learning.
4. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M.,Bretscher, A., Ploegh, H., Amon, A. and Scott, M.P., *Molecular Cell Biology* (2013) 7th ed., W.H. Freeman & Company (New York).

19UBCCC403	Core -11: Molecular Biology	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

- Describe the general principles of gene organization and expression in both prokaryotic and eukaryotic organisms.
- Demonstrate knowledge and understanding of the molecular machinery of replication, recombination and mutation in living cells
- Compare and contrast the mechanisms of bacterial and eukaryotic Transcription, and Translation.
- Understand the molecular mechanisms behind different modes of gene regulation in bacteria and eukaryotes at both pre- and post-transcriptional levels.

Unit 1: Sequencing and Replication of DNA in Prokaryotes and Eukaryotes [12 Hrs]

- Maxam-Gilbert's, Sanger's and automated methods for DNA sequencing.
- Overview of Human genome project.
- DNA polymerase & other enzymes and proteins in DNA replication
- Stages of replication of *E. coli* chromosome.
- Replication in eukaryotes.
- Inhibitors of DNA Replication

Unit 2: Transcription in Prokaryotes and Eukaryotes [12 Hrs]

- Enzymes and factors involved in transcription process.
- Stages of transcription- initiation, elongation and termination
- Post transcriptional modifications- capping, tailing and splicing.
- Comparison between prokaryotic and eukaryotic transcription.
- Inhibitors of transcription and their applications.

Unit 3: Translation in Prokaryotes and Eukaryotes [12 Hrs]

- Genetic code and its characteristics.
- Role of Ribosomes and different types of RNA.
- Charging of tRNA and stages of translation-, initiation, elongation and termination

- Comparison between prokaryotic and eukaryotic translation.
- Post translational modifications
- Inhibitors of protein synthesis and applications in medicine.

Unit 4: Molecular basis of mutations and various modes of DNA repair [12 Hrs]

- Types of mutations - transition, transversions, frame shift mutations, point mutation etc.
- Physical & Chemical Mutagenic agents and Ames test.
- Replication errors and mismatch repair system,
- Repair of DNA damage: direct repair, base excision repair, nucleotide excision repair, recombination repair, SOS response, translesion DNA synthesis.

Unit 5: Recombination and transposable elements [12 Hrs]

- Recombination in bacteria- conjugation, transduction & transformation
- Homologous and Non Homologus recombination
- Site-specific recombination,
- Transposable elements and their classes.
- Importance of transposable elements in horizontal transfer of genes and evolution.

Text Books:

1. Malacinski, G. M., & Freifelder, D. (2015). *Essentials of molecular biolo*gy. Boston, Mass: Jones and Bartlett Publishers. (Unit 1-5)
2. Nelson, D. L., Cox, M. M., & Lehninger, A. L. (2013). *Lehninger principles of biochemistry*. New York: W.H. Freeman. (Unit 1-5)

Reference books

1. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2014).*Molecular biology of the gene*. Boston: Pearson.
2. Snustad, D. P., & Simmons, M. J. (2016). *Principles of genetics*. 5th ed., John Wiley & Sons Asia,
3.Weaver, R. F., & Wassarman, D. A. (2016). I *Molecular biology*. McGraw-Hill Education, New York.

19UBCCC404	Core Practical 4: Biochemistry Practicals- IV	6 Hrs/wk	3 Credits

Objectives:

To enable the students to

- Comprehend the role of various metabolites in the human body & their clinical significance.
- Understand the chemistry and significance of nucleic acids in living systems.

List of Practicals:

1. Introduction to clinical biochemistry practicals and significance of estimation of different biochemical compounds in blood /plasma.
2. Estimation of blood glucose by GOD/POD method.
3. Estimation of plasma urea by urease method.

4. Estimation of serum uric acid by uricase method.
5. Estimation of Total proteins from plasma by biuret method and albumin by BCG method.
6. Calculation of globulin content and A/G ratio.
7. Determination of total cholesterol from plasma sample by enzymatic method.
8. Estimation of triglycerides from plasma samples by enzymatic method.
9. Determination of HDL cholesterol from plasma sample by PTA and enzymatic method.
10. Different tests of lipid profile, their normal values and clinical significance: Triglycerides, VLDL, total cholesterol, LDL cholesterol and HDL cholesterol.
11. Isolation of chromosomal DNA from *E. coli* cells.
12. Ultraviolet absorption spectrum of DNA and RNA.
13. Determination of DNA and RNA concentration by A260nm.
14. Quantitative estimation of DNA by Diphenyl amine method.
15. Quantitative estimation of RNA by orcinol method.
16. Determination of the melting temperature and GC content of DNA.
17. Bacterial recombination through conjugation.

Reference Books:

1. Wilson, K., & Walker, J. M. (2000) *Principles and techniques of practical biochemistry*. Cambridge: Cambridge University Press.
2. J. *Jayaraman* (2011) *Laboratory Manual in* Biochemistry *New Age International Publishers, New Delhi.*
3. Thimmaiah S.R. (2004) *Standard Methods of Biochemical* Analysis. Kalyani Publishers, New Delhi.