Enclosure- I

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

Department of Biochemistry
B.Sc. BIOCHEMISTRY Syllabi for Semester III & IV

SEMESTER -III

16UBCCC08	Core -6: Enzymology	4 Hrs/wk	4 Credits

Objectives:

To enable students to

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

Unit 1: Introduction to enzymes Features of enzyme catalysis [9 Hrs]

- Nature 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,
- Catalysis, reaction rates and thermodynamics of reaction.
- Catalytic power and specificity of enzymes (concept of active site),
- Fischer's lock and key hypothesis,
- Koshland's induced fit hypothesis.

Unit 2: Enzyme kinetics [9 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. Km and 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).
- Differentiating bi substrate mechanisms (diagnostic plots, isotope exchange).

Unit 3: Role of coenzymes and Mechanism of action of enzymes [10 Hrs]

- Role of coenzymes in enzyme reactions:TPP, FAD, NAD, pyridoxal phosphate, biotin, coenzyme A, tetrahydrofolate, lipoic acid.
- General features - proximity and orientation, strain and distortion, acid base and covalent
- Catalysis (chymotrypsin, lysozyme).
- Metal activated enzymes and metalloenzymes,

- Transition state analogues

Unit 4: Enzyme inhibition and Regulation of enzyme activity [10 Hrs]

- Reversible inhibition (competitive, uncompetitive, non-competitive, mixed and substrate).
- Mechanism based inhibitors - antibiotics as inhibitors.
- Control of activities of single enzymes (end product inhibition) and metabolic pathways,
- Feedback inhibition (aspartate transcarbomoylase),
- Reversible covalent modification phosphorylation (glycogen phosphorylase).
- Proteolytic cleavage- zymogen**.**
- Multienzyme complex as regulatory enzymes.
- Occurrence and isolation, phylogenetic distribution and properties (pyruvate dehydrogenase, fatty acyl synthase)
- Isoenzymes - properties and physiological significance (lactate dehydrogenase).

Unit 5: Applications of enzymes [10 Hrs]

- Clinical and diagnostics Application of enzymes (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases), enzyme therapy (Streptokinase). enzyme immunoassay (HRPO),
- Application of enzymes in industries-
- Production of glucose from starch, cellulose and dextran; use of lactase in dairy industry; production of glucose-fructose syrup from sucrose; use of proteases in food, detergent and leather industry.
- Basic Introduction to Immobilized enzymes and their applications.

Text Books

1. Nicholas C.Price and Lewis Stewens Fundamentals of Enzymology (1999) 3rd ed., Oxford University Press Inc. (New York),
2. Jain, J. L. Sunjay Jain and Nitin Jain (2004). Fundamentals of biochemistry. S. Chand Publishing, New Delhi.

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.

16UBCCC09	Core 7:Analytical Biochemistry	4 hrs/wk	4 Credits

Objectives:

To enable the students to

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

Unit 1: Spectroscopic techniques [10 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 [9 Hrs]

- Sedimentation- the concepts of Centrifugal force (F) and Relative centrifugal force (RCF). Over view of 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 [9 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 [10 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 [10 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.
2. Wilson K. and Walker J. (2010) Principles and Techniques of Biochemistry and Molecular Biology 7th Edition, Cambridge: Cambridge University Press.

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.

16UBCCC010	Core -8: Concepts in Genetics	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

- Have working knowledge of classical (transmission) and molecular genetics.
- Study population genetics, analyse quantitative characters and analyze & solve genetics problems.

Unit 1: Basics of Mendelian genetics [10 hrs]

- Basic principles of heredity.
- Laws of probability & binomial expansion,
- Chromosomal basis of Mendelism -Sutton and Boveri hypothesis.
- Allelic variation and gene function - dominance relationships, multiple alleles, lethal alleles and null alleles.
- Pleiotropy gene interaction - epistatic and non epistatic,
- Interaction between gene(s) and environment.

Unit 2: Linkage, crossing over and pedigree analysis. [10 hrs]

- Linkage, crossing over and pedigree analysis.
- Characteristics of dominant and recessive inheritance.
- Applications of pedigree analysis.

Unit 3: Overview on population genetics [10 hrs]

- Introduction to Population Genetics
- Micro population
- Genetic drift
- Migration, Non random Heterozygote advance.. gene pool
- Hardy-Weinberg law, predicting allele and genotype frequencies
- Exceptions to Hardy-Weinberg principle.

Unit 4: Chromosomal Aberrations [9 hrs]

- Numerical- Euploidy (Monoploidy, Haploidy and Polyploidy) Polyploidy- Autopolyploidy and Allopolyploidy. Aneuploidy- Monosomes, Nullisomes and Trisomes.
- Structural- Deletions, Duplication, Translocation and Inversions.
- Evolutionary significance of chromosomal aberrations.

Unit 5: Evolutionary genetics [10 hrs]

- Molecular evolution - analysis of nucleotide and amino acid sequences,
- Molecular phylogenies,
- Homologous sequences,
- Phenotypic evolution and speciation.
- Natural Selection
- Chemical and Biological evolution

Textbooks

1. Verma, P. S., & Agarwal, V. K. (2005). Cell biology. Molecular Biology, Evolution and Ecology. S Chand & Company Ltd. Ram Nagar, New Delhi.
2. Green, N. P., Stout, G. W., Taylor, D. J., & Soper, R. (1998). Biological Science 1 & 2. Cambridge University Press.

Reference books

1. Gardner, E. J., Simmons, M. J., & Snustad, D. P. (2016). Principles of genetics (No. Ed. 8). John Wiley and Sons, Inc..
2. Pierce, B. A. (2012). Genetics: A conceptual approach. W.H. Freeman & Co.
3. Carroll, S. B., Doebley, J. F., Griffiths, A. J., & Wessler, S. R. (2015).Introduction to genetic analysis., W.H. Freeman & Company (New York)

16UBCCC011	Enzymology and Analytical Biochemistry Practical	6 Hrs/wk	3 Credits

Objective

To enable the students to

1. Carry out an enzyme experiment at different temperatures, pH values, enzyme concentrations and substrate concentrations.
2. Explain and apply the basic principles of various biochemical techniques.

List of Practicals:

1) An introduction to practicals in enzymology.
2) Assay of enzyme Acid Phosphatase.
3) Enzyme curve of Acid Phosphatase.
4) Substrate curve of Acid Phosphatase.
5) pH curve of Acid Phosphatase.
6) Temperature Curve of Acid Phosphatase.
7) Determination of Specific activity of enzyme.
8) Estimation of SGPT/ SGOT
9) Estimation of CPK.
10) Introduction to principle and working of Colorimeter and spectrophotometer.
11) Determination of absorption spectrum and absorption maxima of given compound.
12) Verification of Beer's Law of light absorption using colored solutions.
13) Introduction to principle and working of centrifuge.
14) Separation of amino acids using paper chromatography. Determination of Rf values and identification of amino acids from mixtures.
15) Separation of lipids by thin layer chromatography.
16) Separation of compounds using column chromatography.
17) Separation of Dyes using chalk chromatography.

18) 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

16UBCCC12	Core -9: Metabolism	4 Hrs/wk	4 Credits

Objectives:
To enable the students to

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

Unit 1: Basic design and metabolism of carbohydrate [10 Hrs]

- Autotrophs, heterotrophs
- Metabolic pathways, catabolism, anabolism
- ATP as energy currency,
- 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. Glycogen storage diseases and other inborn errors of metabolism galactosemia and lactose intolerance.
- Glyoxalate pathway and its significance in plants.

Unit 2: Citric acid cycle [09 Hrs]

- Fates of pyruvate
- 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.

Unit 3: Metabolism of lipids [10 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, brief overview of oxidation of unsaturated and odd numbered fatty acids
- Fatty acid synthase complex as a multienzyme complex and synthesis of fatty acids. Comparision of fatty acid synthesis and fatty acid oxidation

- Ketone bodies metabolism, Causes and reasons 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 [10 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 [9 Hrs]

- Chemical Structures of purine and pyrimidine bases nucleoside ,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. Campbell, N. A., & Reece, J. B. (2016). Campbell biology: Concepts & connections. Boston: Pearson
2. Deb, A. C. (2006). Fundamentals of Biochemistry. Calcutta, India: New Central Book Agency.

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. 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.

16UBCCC13	Core -10: Membrane Biology and Bioenergetics	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

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

Unit 1: Introduction to biomembranes [9 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 [10 Hrs]

- Thermodynamics of transport. Simple diffusion and facilitated diffusion.
- Passive transport -glucose transporter, anion transporter and porins**.**
- 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 [9 Hrs]

- Pinocytosis
- Phagocytosis-exocytosis and endocytosis
- Receptor mediated endocytosis of LDL
- Liposome mediated drug delivery systems and its applications

Unit 4: Introduction to bioenergetics [10 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 phosphorylated compounds and thioesters.

Unit 5: Mitochondrial, Electron transport chain & Oxidative phosphorylation [10 Hrs]

- Mitochondria. Electron transport chain - its organization and function.
- Inhibitors of ETC and uncouplers.
- Basic Introduction to Peter Mitchell's chemiosmotic hypothesis. Proton motive force.
- Fo F1ATPase : structure and mechanism of ATP synthesis.
- Regulation of oxidative phosphorylation.

Text Books

1. Campbell, N. A., & Reece, J. B. (2016). Campbell biology: Concepts & connections. Boston: Pearson

2. Deb, A. C. (2006). Fundamentals of biochemistry. Calcutta, India: New Central Book Agency.

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).

16UBCCC14	Core -11: Molecular Biology-I	4 Hrs/wk	4 Credits

Objectives:

To enable the students to

1. Describe the general principles of gene organization and expression in both prokaryotic and eukaryotic organisms.
2. Demonstrate knowledge and understanding of the molecular machinery of replication, recombination and mutation in living cells

Unit 1: Structure of DNA **[6 Hrs]**

- DNA structure
- Features of the double helix,
- Various forms of DNA
- Denaturation and reassociation of DNA.

Unit 2: Genes and genomic organization **[10 Hrs]**

- Genome sequence and chromosome diversity,
- Definition of a gene, organization of genes in viruses, bacteria, animals and plants.
- Nucleosome structure and packaging of DNA into higher order structures.

Unit 3: Replication of DNA **[10 Hrs]**

- The chemistry of DNA synthesis
- DNA polymerase & other enzymes and proteins in DNA replication
- Stages of replication of *E. coli* chromosome,
- Relationship between replication and cell division,
- Replication in eukaryotes.
- Inhibitors of DNA

Unit 4: Recombination and transposition of DNA **[10 Hrs]**

- Homologous recombination,
- Proteins and enzymes in recombination,
- Site-specific recombination,
- Biological roles of site-specific recombination,
- Transposition, three classes of transposable elements,
- Importance of transposable elements in horizontal transfer of genes and evolution.

Unit 5: Molecular basis of mutations and various modes of DNA repair [10 Hrs]

- Importance of mutations in evolution of species.
- Types of mutations - transition, transversions, frame shift mutations,
- Mutations induced by chemicals, radiation,
- Ames test.
- Replication errors and mismatch repair system,
- Repair of DNA damage: direct repair, base excision repair, nucleotide excision repair, recombination repair, translesion DNA synthesis.

Text Books:

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

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.

16UBCCC015	Metabolism and Molecular Biology Practical	6 Hrs/wk	3 Credits

Objectives:

To enable the students to

1. Comprehend the role of various metabolites in the human body & their clinical significance.
2. 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.

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.