ALIGARH MUSLIM UNIVERSITY, ALIGARH

FACULTY OF LIFE SCIENCE
SYLLABUS FOR

M.SC. BIOCHEMISTRY

Biomolecules

Unit-I:	**WATER AND PROTEINS (15 Lectures)** **Water:** Suitability of water as a solvent of life and its properties arising out of its polar nature; Ionization of H_2O and ion product of water; the pH scale; relationship between pH and pKa (Henderson-Hasselbalch equation); weak acids and bases as buffers, importance of buffers in living systems. **Proteins**: Definition, biological functions of proteins; structure of twenty amino acids commonly found in proteins; abbreviations and classification of 20 amino acids; zwitterion nature of amino acids in aqueous solutions; essential amino acids; peptide bond and its properties; backbone structure of proteins; N-terminal and C-terminal amino acids; basic understanding of primary, secondary, tertiary, and quaternary domain structure of proteins/peptides; fibrous and globular proteins; collagen helix; elementary ideas on protein denaturation and renaturation.
Unit-II:	**CARBOHYDRATES (15 Lectures)** Definition, biological functions; classification into monosaccharides (aldoses and ketoses), enantiomers, epimers, anomers in carbohydrates; difference between optical and functional isomers, open chain and ring structures of carbohydrates; mutarotation; structure of biologically important; oligosaccharides and polysaccharides, homo and heteropolymers- mucopolysaccharides; suitability of polysaccharides as storage material.
Unit-III:	**LIPIDS (15 Lectures)** Definition, biological functions, general formulae, nomenclature and properties of fatty acids; essential and non- essential fatty acids; classification of lipids; general structure and function of major lipid subclasses- acylglycerols, phosphoglycerates, sphingolipids, waxes, terpenes, steroids and prostaglandins; saponifiable and non-saponifiable lipids; suitability of triglycerides as storage lipids; saponification number and iodine number.
Unit-IV:	**NUCLEIC ACIDS (15 Lectures)** Nucleosides and nucleotides; generalized structural plan of nucleic acids; Evidence that DNA is the genetic material; Watson-Crick model of DNA; size of DNA in prokaryotic and eukaryotic cells; Basic idea of RNAs types, structure and function; gene, genome and chromosome; genetic code and codons. Central dogma of molecular biology; Mutations-definition.

Books Recommended:

1. Lehninger: Principles of Biochemistry (2017) by Nelson and Cox. Seventh edition. W H Freeman and Co.
2. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. Eighth Edition. W H Freeman and Co.
3. Introducing Biochemistry (1982) by Wood and Pickering. ELBS/John Muray.

Structure and Function of Cell

Unit-I:	**CELL AND ITS ORGANELLES (7 Lectures)** Structure and function of key organelles - mitochondria, nucleus, endoplasmic reticulum, golgi apparatus, lysosome, peroxisome and microbodies. Structure of a typical plant cell: cell wall, chloroplast and vacuole.
Unit-II:	**MEMBRANE STRUCTURE & FUNCTION (8 Lectures)** Functions of biological membranes. Composition - nature of lipids, proteins, carbohydrates and other molecules. Model membranes-monolayer, bilayer, liposomes. Singer and Nicholson model (fluid-mosaic model). Factors affecting membrane fluidity and asymmetry. Transport function of membranes, active and passive transport of various substances; transport via vesicle formation. Electrical properties of membrane.
Unit-III:	**CYTOSKELETON AND BASIC MICROSCOPY (8 Lectures)** a) Structure and organization of the key cytoskeletal filaments: microfilaments, microtubule and intermediate filaments. Assembly and movement of cilia and flagella. b) Visualization of cells and sub-cellular components by light microscopy, different fixation and staining techniques for EM, freeze itch and freeze fracture methods for EM.
Unit-IV:	**CELL CYCLE, CELL DEATH & CANCER (7 Lectures)** Cell division-mitosis and meiosis; eukaryotic cell cycle- steps and control of cell cycle. Restriction points and check points. Brief outline of apoptosis and necrosis. Salient features of a transformed cell.

Books Recommended:

1. Cell Biology (2012) by G. Karp. Seventh edition,Wiley.
2. Molecular Biology of the Cell (2014) by Alberts, Johnson, Lewis, Raff, Roberts, Walter. Sixth edition, Garland Publishing Inc. New York, USA.
3. Molecular Cell Biology (2016) by Eighth Edition.W. H. Freeman & Co. Ltd
4. Molecular Cell Biology (1986) by C J Avers.Third edition, Addison Wesley, USA.
5. Cell Biology (2005) by S C Rastogi. Third edition, Tata McGraw Hill Publishing Co, New Delhi.

Fundamentals of Biochemistry

Unit-I:	**WATER AND PROTEINS (15 Lectures)** Importance of water as a solvent for life: Generalized discussion on how water is important to support life, the structure of the water molecule, its angles and dipole moment. Role of the dipole in formation of hydrogen bonds. Structure of water as a fluid with hydrogen bonds, and its impact on the physical properties of water. Ionization of water, the pH scale: biological relevance of pH, the near neutral pH of body fluids, the acidic environment of the stomach and the alkaline environment of the intestine, examples of enzymes that work in such extreme environments. Buffers: Introduction to buffers, buffering action, the Handerson-Hasselbach equation with derivation. Definition of amino acids, alpha amino acids, the structure of 20 alpha amino acids, their 3 letter codes and single alphabet notations. Acidic, basic, hydrophobic amino acids. The peptide bond, its formation, discussion of the peptide bond with reference to glutathione. N and C terminus of a peptide. The primary, secondary, tertiary and quaternary structure of proteins. Denaturation and renaturation of proteins. Examples of denaturation from everyday life (boiling of eggs, making of cottage cheese (paneer).
Unit-II:	**CARBOHYDRATES (15 Lectures)** Definition of carbohydrates, carbohydrate rich food, role of carbohydrates as energy sources, other biological function of carbohydrates, aldoses and ketoses with examples, structure of glucose, fructose, galactose, sucrose, maltose, ribose, deoxy ribose. Pyranose and Furanose rings with examples of D Glucose and D Fructose. Carbohydrates as energy sources. Structure of starch (amylose and amylopectin), structure of glycogen, advantages of storing glycogen and not glucose in the body, cellulose, structure and function.
Unit-III:	**LIPIDS (15 Lectures)** Definition, biological functions, essential and non essential fatty acids, saturated and unsaturated fatty acids. Examples of fatty acids with double bonds. Triglycerides: structure and function. Role of triglycerides as storage lipids, Phospholipids: structure and function, role of phospholipids in the lipid bilayer, Singer and Nicolson Model of bilipid layer. Cholesterol: structure, dietary sources, role in the lipid bilayer.
Unit-IV:	**NUCLEIC ACIDS (15 Lectures)** Generalized structural plan of nucleic acids. Nucleotides and Nucleosides. Structure of Adenine, Thymine, Cytosine, Guanine and Uracil. Watson and Crick Base pairing with structure.DNA: Watson and Crick Model, biological consequences of the double helix. A, B and Z form of DNA, G Quadruplexes. Gene and Genome. Chromosomes RNA: Structure of RNA, Central Dogma of Molecular Biology, Reverse Transcription mRNA, tRNA, rRNA: biological roles, genetic code, codon and anticodon.

Books Recommended:

1. Lehninger: Principles of Biochemistry (2017) by Nelson and Cox. 7th Edition. WH Freeman Co.
2. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. 8th Edition. WH Freeman and Co.
3. Introducing Biochemistry (1982) by Wood and Pickering. ELBS/ John Muray

Molecular Basis of Life

Unit-I:	**INTRODUCTION TO LIFE (15 Lectures)** What is life? Life can be understood in terms of chemistry. Importance of water as a solvent for life: Generalized properties of water, the structure of the water molecule, its angles. Ionization of water, What is pH? The pH scale: biological relevance of pH, the near neutral pH of body fluids, the acidic environment of the stomach and the alkaline environment of the intestine. What are buffers? Examples. Oxidation, Reduction and Redox Reactions.
Unit-II:	**CARBOHYDRATES AND PROTEINS (15 Lectures)** Definition of carbohydrates, carbohydrate rich food, role of carbohydrates as energy sources, other biological function of carbohydrates. Aldoses and ketoses with examples, structure of glucose, fructose Polysaccharides, Function of starch, glycogen and cellulose. Preliminary idea of structure of polysaccharides. Amino acids. Acidic, basic, hydrophilic and hydrophobic amino acids. What are zwitter ions? Proteins, Peptides, Proteins as material that build the body. Functions of Proteins. Enzymes as biological catalysts.
Unit-III:	**LIPIDS (15 Lectures)** Definition, biological functions and structure of fatty acids, essential and non essential fatty acids, saturated and unsaturated fatty acids. Examples of fatty acids with double bonds. Triglycerides: structure and function. Role of triglycerides as storage lipids, Phospholipids: structure and function, role of phospholipids in the lipid bilayer, Cholesterol: structure, dietary sources, role in the lipid bilayer.
Unit-IV:	**NUCLEIC ACIDS (15 Lectures)** Definition of nucleic acids and their role in heredity and inheritance, generalized structural plan of nucleic acids. Nucleotides and Nucleosides. DNA: Watson and Crick Model, biological consequences of the double helix. Gene and Genome. Chromosomes – Eukaryotes and Prokaryotes. RNA: Structure of RNA, Central Dogma of Molecular Biology, mRNA, tRNA, rRNA : biological roles.

Books Recommended:

1. Lehninger: Principles of Biochemistry (2017) by Nelson and Cox. 7th Edition. WH Freeman and Co.
2. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. 8th Edition. WH Freeman and Co.
3. Introducing Biochemistry (1982) by Wood and Pickering. ELBS/ John Muray

Microbiology

Unit-I:	**CRITERIA FOR IDENTIFICATION & CLASSIFICATION (15 Lectures)** Brief introduction to microorganisms; history and scope of microbiology; different kingdom systems of life (two kingdom system to three domains of life; binomial nomenclature; criteria used in the classification & identification of bacteria: morphology, cytology, genetics, host specialization, serology, physiology etc.; general methods used in classifying bacteria: numerical taxonomy, genetic relatedness and DNA & RNA homology.
Unit-II:	**BACTERIAL MORPHOLOGY (15 Lectures)** General organization of bacterial cells: External structures (cell wall, outer cell membrane, periplasmic space, flagella, pili and glycocalyx) and Internal structures (cell membrane, cytoplasm, ribosomes, nuclear region, membranous intrusions, internal membrane system, cytoplasmic inclusions and vacuoles); difference in gram positive, gram-negative and acid fast bacterial cell wall; structure and function of peptidoglycan, lipopolysacchrides and teichoic acid; difference between endotoxin and exotoxin; introduction to different types of bacterial spores and cysts (endospore, exospores, conidiospore, sporangiospore and cysts) types of endospores on the basis of their shape and location within the bacterial cell; structure of endospore; different stages of sporulation and germination.
Unit-III:	**BACTERIAL GROWTH & PHYSIOLOGY (15 Lectures)** Bacterial growth; formula for initial and final population of bacteria by binary fission after varying numbers of generations; different types culture (batch and continuous culture); continuous culture devices (chemostat & turbidostat); phases of growth in batch culture (lag, log, stationary and decline phase); formula for growth rate and generation time; Culture media: types and commonly used media (selective, differential and enrichment media); Difference between synchronous and non-synchronous growth and their use; Measurement of bacterial growth: direct methods (direct microscopic count, electronic enumeration of cells, plate count, filteration and MPN test) and indirect methods (turbidimetric, nitrogen content determination, cell dry weight determination, measurement of biochemical activity); Difference between total and viable cell counts (CFU); Factors affecting bacterial growth: physical factors (pH, temperature, oxygen requirements, moisture, hydrostatic and osmotic pressure and radiation) and nutritional factors (carbon, nitrogen, sulphur, phosphorus, trace elements, vitamins, nutritional complexity).
Unit-IV:	**BACTERIAL GENETICS (15 Lectures)** Definition of genotype and phenotype; effect of environment on phenotypic changes and mutation on genotypic change; types of mutations (point, frame shift, spontaneous and induced mutation) and their effects; types and significance of gene transfer in bacteria (lateral and vertical gene transfer); methods of lateral gene transfer: transformation, transduction and conjugation (their discovery, mechanism and significance); generalized and specialized transduction.

Books Recommended:

1. J. G. Black, Microbiology Principles and Explorations (2004) John Wiley and Sons, Inc
2. E. Alcamo, Fundamentals of Microbiology (2013) The Benjamin/Cummings Publishing Co. Inc., California, USA
3. M. Pleczar, E.C.S. Chan and M.R. Krieg, Microbiology (1997), MacGraw Hill Inc, Singapore
4. Tortora, Funke and Case Microbiology and Introduction by Pearson Education, Inc.

Virology

Unit-I:	**MORPHOLOGY OF VIRUSES (07 Lectures)** Introduction to viruses, early history of virology, general features of viruses and differences from bacteria. Viroids: general features and diseases, Virusoids: general features and diseases, Prions: general features and diseases. Structure of viruses, variation in shape and symmetry, basic discussion on helical, icosahedral and complex symmetry. Role and origin of viral envelope. Viral Enzymes. Capsid, capsomeres and viral nucleic acids.
Unit-II:	**LIFE CYCLE OF VIRUSES (08 Lectures)** Introduction to viral reproduction, Lytic cycle of bacteriophages and examples. Lysogenic cycle of bacteriophages and examples. Life Cycle of DNA viruses with examples, Life Cycle of RNA Viruses. Positive and negative strand RNA viruses with examples. Replication of retroviruses, Reverse transcription and Reverse transcriptase.
Unit-III:	**VIRAL CULTIVATION AND ASSAYS (07 Lectures)** Methods of cultivation of animal viruses, role of cell culture and animal models, the fertilized egg as a model for cultivation of viruses. Cultivation of Phages, plaque formation assay and cytopathic effects of viruses (general discussion), hemagglutination assay.
Unit-IV:	**VIRAL INFECTIONS (08 Lectures)** General discussion on Tissue Tropism: Neurotropic, Dermatropic, Pneumotropic, Viscerotropic Viruses with examples. Zoonotic Viruses: discussion with examples. Acute Viral Infections: Discussion on Influenza, Persistent Viral Infections: Discussion on Hepatitis. AIDS: General Discussion, treatment options and COVID: introduction to viral epidemics, symptoms of COVID, treatment and very basic discussion on the available vaccines for COVID.

Books Recommended:

1. J. G. Black, Microbiology Principles and Explorations (2004) John Wiley and Sons, Inc
2. E. Alcamo, Fundamentals of Microbiology (2013) The Benjamin/Cummings Publishing Co. Inc., California, USA
3. M. Pleczar, E.C.S. Chan and M.R. Krieg, Microbiology (1997), MacGraw Hill Inc, Singapore

Introductory Microbiology

Unit-I:	**CRITERIA FOR CLASSIFICATION (15 Lecture)** Microbial world; a brief introduction, scope of microbiology, Five kingdoms to three domains of life, microbes in the three domains of life: criteria used in the characterization, classification & identification of bacteria - morphology, cytology, genetics, host specialization, serology, physiology etc.; Problems in bacterial taxonomy, general methods used in classifying bacteria; numerical taxonomy and genetic relatedness.
Unit-II:	**BACTERIAL CELL STRUCTURE & FUNCTION (15 Lecture)** An overview of bacterial cell structure- Key differences in prokaryotic and eukaryotic cells, Cell membrane, the cytoplasmic matrix, features of the bacterial genome, the nucleoid, plasmids, episomes; the bacterial cell wall, structure and function of peptidoglycan, differences in the Gram positive and Gram-negative cell walls; Components external to the cell wall; capsule and slime layers, pili and fimbriae & flagella; the difference in eukaryotic and prokaryotic flagella.
Unit-III:	**MICROBIAL GROWTH (15 Lectures)** Modes of cell division in bacteria; Growth in batch culture, phases of growth; lag, log, stationary and decline phase, synchronous and non-synchronous growth; continuous culture device; chemostat, Physical factors affecting bacterial growth; pH, temperature and oxygen requirements, Sporulation; bacterial endospores.
Unit-IV:	**GENE TRANSFER IN BACTERIA (15 Lecture)** Gene transfer in bacteria; vertical and lateral/horizontal gene transfer, Methods of lateral gene transfer: transformation, transduction and conjugation; Generalized and specialized transduction; temperate and virulent phages, lysogenic and lytic cycles.

Books Recommended:

1. J. G. Black, Microbiology Principles and Explorations (2004) John Wiley and Sons, Inc
2. E. Alcamo, Fundamentals of Microbiology (2013) The Benjamin/Cummings Publishing Co. Inc., California, USA
3. M. Pelczar, E. C. S. Chan and M. R. Krieg, MICROBIOLOGY, McGraw Hill Inc., Singapore (1997).
4. Tortora, Funke and Case Microbiology: An Introduction by Pearson Education, Inc.

Introduction to Viruses

Unit-I:	**MORPHOLOGY OF VIRUSES (15 Lectures)** What are viruses, their discovery, differences from bacteria, general features of viruses, variation in viral size and symmetry, what are Viroids: Examples and Diseases, Prions: general features, diseases caused by prions, Virusoids: general introduction and diseases caused by virusoids. The viral envelope, capsid, capsomeres and nucleic acid genome of viruses, general examples of DNA and RNA Viruses.
Unit-II:	**LIFECYCLE OF VIRUSES (15 Lectures)** General introduction to Viral reproduction, descriptive discussion of Lytic bacteriophages with examples, descriptive discussion of lysogenic bacteriophages with examples. Life cycle of a DNA virus with example and diagrams. Life cycle of RNA viruses with examples, positive strand and negative strand RNA viruses. General discussion of a retrovirus, reverse transcription and reverse transcriptase. Viruses and Cancer: cell proliferation, discussion of human oncoviruses and their effects on cell growth.
Unit-III:	**VIRAL CULTIVATION AND ASSAYS (15 Lectures)** Introduction to the methods of cultivation of animal virus, cell culture, fertilized egg and live models. Plaque formation assay and hemagglutination assay. Details and Function General discussion of the pathological presentation by viruses. Cytopathic effects of viruses (general discussion)
Unit-IV:	**VIRAL INFECTIONS (15 Lectures)** Host specificity and tissue selectivity of viral infections with examples. Zoonotic viruses. Tissue Tropism: Neurotropic, Dermatropic, Pneumotropic, Viscerotropic Viruses, definition, general discussion and examples. Acute viral infections with discussion on influenza and chronic viral infections with a discussion of hepatitis.

Books Recommended:

1. J.G. Black, Microbiology Principles and Explorations (2004) John Wiley and Sons, Inc
2. E. Alcamo, Fundamentals of Microbiology (2013) The Benjamin/Cummings Publishing Co. Inc., California, USA
3. M. Pleczar, E.C.S. Chan and M.R. Krieg, Microbiology (1997), MacGraw Hill Inc, Singapore

Enzymology

Unit-I:	**INTRODUCTION (15 Lectures)** Definition, historical perspective, IUB enzyme classification (rationale, overview and specific examples). Nature of non-enzymatic and enzymatic catalysis. Measurement and expression of enzyme activity, enzyme assays. Definition of IU, enzyme turn over number and specific activity. Role of non-protein organic molecules and inorganic ions, co-factors, coenzymes, prosthetic groups. Role of vitamins as coenzyme precursors (general treatment), details of coenzyme functions of NAD and pyridoxal phosphate.
Unit-II:	**MECHANISM OF ENZYME ACTION (15 Lectures)** Nature of substrate binding sites, active sites of enzymes. Collision and transition state theory. Michaelis-Menten equation, determination and significance of V_{max} and K_M. Lock and key and induced fit model of enzyme-substrate interactions. Enzyme catalytic efficiency, proximity, orientation, distortion or strain, acid-base and nucleophilic catalysis.
Unit-III:	**ENZYME KINETICS & ALLOSTERIC ENZYMES (15 Lectures)** Kinetics of zero and first order reactions, effect of enzyme concentration, substrate concentration, temperature and pH on enzyme activity; Basis of enzyme inhibition (reversible and irreversible inhibition). Evaluation of K_m, K_i and V_{max} in the presence of inhibitors. Significance and evaluation of energy of activation and free energy.
Unit-IV:	**INDUSTRIAL AND CLINICAL APPLICATION OF ENZYMES (15 Lectures)** Industrial uses of enzymes; production of glucose from maltose, starch, cellulose and dextran; use of lactase in diary industry; production of glucose-fructose syrup from sucrose. Use of proteases in food, detergent and leather industries. Medical applications of enzymes; use of glucose oxidase in enzyme electrodes.

Books Recommended:

1. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. Eighth Edition.
2. Biochemistry (1998) by G L Zubay. Fourth edition. W. C. Brown Publishers, USA
3. Lehninger: Principles of Biochemistry (2017) by Nelson and Cox Seventh edition.
4. Biochemical Calculations by Irwin H. Segel
5. Fundamentals of Enzymology (2000) by N. Price and L. Stevens.
6. Understanding Enzymes by Trevor Palmer

Nutritional Biochemistry

Unit-I:	**INTRODUCTION TO NUTRITION (07 Lectures)** Definition, types and functions of nutrients. Definition and unit of energy. Estimation of energy requirement and energy expenditure with reference to man. Recommended nutrient intakes (RNI) and recommended dietary allowances (RDA) for different age groups. Prebiotics and Probiotics.
Unit-II:	**DIETARY CARBOHYDRATES AND LIPIDS (08 Lectures)** a) Types and functions of carbohydrates. Dietary requirements and source of carbohydrates. Dietary fiber- sources and their role in health. b) Classification, sources, functions, and storage of lipids. Importance of the following in the body: Omega – fatty acids; ratio of Omega3 and Omega6 fatty acids; Phospholipids; Cholesterol; mono and polyunsaturated fatty acids and saturated fatty acids.
Unit-III:	**DIETARY PROTEINS (08 Lectures)** Definition, classification, structure, functions and sources of proteins in the body. Essential and non-essential amino acids and their roles. PEM and Kwashiorkor.
Unit-IV:	**VITAMINS AND MINERALS (07 Lectures)** Vitamins: classification, functions, sources and deficiencies. Minerals: calcium, phosphorus, and iron - distribution in the body, utilization, deficiency, toxicity, sources. Role of iron in prevention of anemia, Calcium: Phosphorus ratio.

Books Recommended:

1. Biochemistry Illustrated by Peter N. Campbell, Anthony D. Smith
2. Textbook of Biochemistry with Clinical Correlations (2011) by TM Devlin. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
3. Essentials of Clinical Nutrition (1988) by EB Feldman. Davis Company ISBN-0-8036- 3431-
4. Principles of Nutritional Assessment (2005) Rosalind Gibson. Oxford University Press.
5. Krause's Food and Nutrition Care process. (2012); Mahan, L.K Strings,S.E, Raymond,J. Elsevier's Publications. ISBN-978-1-4377-2233-8.

Introduction to Biocatalysts

Unit-I:	**ENZYMES: A BEGINNER'S GUIDE (15 Lectures**) Basic definition of enzyme, historical background, nomenclature and classifications. Characteristics of non-enzymatic and enzymatic catalysis. Estimation and expression of enzyme activity, enzyme probes. Enzyme turnover number, IU and specific activity. Concept of holoenzyme and roles of inorganic ions, non-protein organic molecules, co enzymes and prosthetic groups. Vitamins as coenzyme precursors. NAD and pyridoxal phosphate coenzyme activities in detail.
Unit-II:	**ENZYME ACTION MECHANISM (15 Lectures)** Significance and evidences for the formation of enzyme-substrate complex. Characteristic features of active sites of an enzyme and substrate binding sites. Collision and transition state theory for enzyme catalyzed reactions. Description of Michaelis-Menten equation, V_{max} and K_M. Models of enzyme-substrate interactions and catalytic efficiency of enzyme. Mechanisms of enzyme catalysis and stereo-specificity of enzymes for substrates.
Unit-III:	**ENZYME KINETICS (15 Lectures)** Zero and first order kinetics of enzyme catalyzed reactions. Factors effecting the rate of enzyme catalyzed reactions. Types of enzyme inhibitions (reversible and irreversible). Estimation of K_M, K_i and V_{max} of enzyme catalyzed reactions in the presence of inhibitors. The importance of activation energy and free energy, as well as their evaluation. Brief description of allosteric enzymes.
Unit-IV:	**ENZYMES IN INDUSTRIAL AND CLINICAL APPLICATIONS (15 Lectures)** Industrial applications of enzymes; glucose production from other carbohydrates, uses of lactose in dairy industry, making of glucose-fructose syrup. Industrial applications of proteases. Clinical applications of enzymes; principle of enzyme electrodes and glucometer.

Books Recommended:

1. Lehninger: Principles of Biochemistry (2021) by Nelson and Cox, eighth edition.
2. Biochemical Calculations by Irwin H. Segel.
3. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. Eighth Edition.
4. Biochemistry (1998) by G L Zubay. Fourth edition. W. C. Brown Publishers, USA
5. Fundamentals of Enzymology (2000) by N. Price and L. Stevens.
6. Understanding Enzymes by Trevor Palmer

Enzymes and its Applications

Unit-I:	**INTRODUCTION TO ENZYMES (15 Lectures)** Definition& properties of enzymes, activity graph in the presence of pH & temperature, IUBMB system, Co-factors and co-enzymes: Metal ions, vitamins, and prosthetic groups, NAD, active site structure and function, Concept of apoenzyme, holoenzyme, ribozymes and abzymes. Definition of IU, enzyme turn over number and specific activity.
Unit-II:	**ENZYME KINETICS (15 Lectures)** Michaelis-Menten kinetics and its significance, Lineweaver-Burk plot and its significance, Factors affecting enzyme activity: Temperature, pH, substrate concentration, and inhibitors. Types of inhibition: Competitive, non-competitive, uncompetitive, and mixed inhibition. V_{max} and K_M and their significance, Enzyme-substrate interaction (lock and key model, induced fit model). Zymogens, Isozymes and Allosteric enzymes
Unit-III:	**APPLICATIONS IN INDUSTRY (15 Lectures)** Enzymes in food, detergent, brewing, cheese making, fruit juice extraction, textiles, dairy and paper industries (amylases, cellulases and Lipase), Enzymes in biofuel production. amylases in baking, proteases in cheese, Detergent enzymes (lipases, proteases). Rennet; coagulation of milk to form curds during cheese production. Hair and skin care enzymes.
Unit-IV:	**MEDICAL, BIOTECHNOLOGICAL & ADVANCED APPLICATION OF ENZYMES (15 Lectures)** Diagnostic enzymes (ELISA, biosensors), Therapeutic enzymes (streptokinase, asparaginase), Enzymes for liver enzymes, cardiac markers, Enzyme electrodes, glucose-fructose syrup from sucrose. Recombinant DNA technology enzyme, PCR Enzyme, Restriction enzymes, Endo and exonucleases, Proteases, Phosphatases and Hexokinases.

Books recommended

1. Lehninger Principles of Biochemistry" by David L. Nelson and Michael M. Cox
2. Biochemistry" by Jeremy M. Berg, John L. Tymoczko, and Lubert Stryer
3. Biochemical Pharmacology" by R. S. S. G. G. Ramasarma
4. Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems" by Irwin H. Segel
5. Enzyme Kinetics: From Diastase to Molecular Machines" by J. M. O'Neill
6. Industrial Enzymes: Structure, Function and Applications" edited by R. A. P. M. W. J. D. H. W. P. N. and T. M. S. W. V. F. W.
7. Enzymes in Industry: Production and Applications" edited by Wolfgang Aehle
8. Enzyme Technology" by Peter J. Hawker
9. Enzymes in Medicine and Biotechnology" by A. G. Engel
10. Biotechnology of Human Protein Expression in Yeast" by R. D. Harvester
11. Biotechnology for Beginners" by Reinhard Renneberg
12. Fundamentals of Enzymology" by Nicholas C. Price and Lewis Stevens

Experimental Skills in Biochemistry

Unit-I:	**CONCEPTS OF SOLUTIONS AND BUFFERS** **(07 Lectures)** Basic concept of dilution, preparation of solutions (stock and working solutions), and concept of concentration, molarity & unit conversion. Concept of pH, acids and bases, buffers. Henderson-Hasselbalch equation, with derivation. Principle, instrumentation and working of pH meter.
Unit-II:	**SPECTROSCOPIC AND CHROMATOGRAPHIC TECHNIQUES** **(08 Lectures)** Principle of spectroscopy, Beer Lambert Law, instrumentation and applications of colorimetry and UV-Visible Spectroscopy. Absorbance/Optical Density, Spectral analysis, Maximum Absorbance (Lambda Max). Determining protein concentration by spectrophotometer, Biuret and Lowry's assays. Determination of glucose concentration by DNS method. Glucose Oxidase Peroxidase method. Introduction to chromatography, size exclusion chromatography.
Unit-III:	**MICROBIAL TECHNIQUES AND MICROBIAL CULTURE** **(07 Lectures)** Introduction to Microbial cultures (bacterial and fungal). Cleaning and sterilization of glassware by dry-heating (Hot-air oven) and wet-heating (Autoclave). Types of culture media, selective media. Bacterial growth curve, growth plot. *E. coli* as model organism.
Unit-IV:	**THE PRINCIPLES OF GOOD LABORATORY PRACTICES** **(08 Lectures)** Universal/standard precautions. Hazards in biochemical laboratories. Organization and personal management responsibilities. Quality control (internal and external) and quality assurance. Standard operating procedures. Storage of records and reports.

Books Recommended:

1. Lehninger: Principles of Biochemistry (2017) by Nelson and Cox. 7th Edition. WH Freeman and Co.
2. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. 8th Edition. WH Freeman and Co.
3. Introducing Biochemistry (1982) by Wood and Pickering. ELBS/ John Muray
4. Practical Biochemistry by Plummer
5. Biochemical Calculations by Irwin H. Segel

Metabolism

Unit-I:	**ANAEROBIC CARBOHYDRATE METABOLISM** **(15 Lectures)** Steps in the breakdown of glucose to pyruvate, fate of pyruvate under anaerobic conditions, fermentation; oxygen debt; feeder pathways for entry of other monosaccarides in glycolysis; gluconeogenesis, regulation of glycolysis and gluconeogenesis at various levels; synthesis and breakdown of sucrose and lactose; synthesis and breakdown of starch and glycogen and its reciprocal regulation; hexose monophosphate shunt pathway and its significance; Diabetes, galactosemia, lactose intolerance.
Unit-II:	**AEROBIC CARBOHYDRATE METABOLISM** **(15 Lectures)** Entry of pyruvate into Kreb cycle; individual reactions of the Kreb cycle; energetics of the cycle; Amphibolic nature of the cycle; regulation of TCA cycle; glyoxalate cycle and its significance; elements of electron transport chain; oxidative phosphorylation; energy coupling hypothesis; uncouplers; Malate- Aspartate and glycerol phosphate shuttles.
Unit-III:	**LIPID METABOLSIM** **(15 Lectures**) Individual reactions of beta-oxidation pathway; oxidation of unsaturated fatty acids and odd chain fatty acid; formation and break down of ketone bodies; biosynthesis of fatty acids and overview of cholesterol biosynthesis, role of cholesterol in biological system; serum lipoproteins (LDL, HDL) and their role in the development of coronary heart disease.
Unit-IV:	**NITROGEN METABOLISM** **(15 Lectures)** Comparative biochemistry of nitrogen excretion, Urea cycle (preliminary account); transamination and deamination reactions; synthesis and breakdown of purines and pyrimidines including regulation (preliminary account); Synthesis of biologically active amines e.g. catecholamines, serotonin, γ- aminobutyric acid, histamine glutathione and creatine.

Books Recommended:

1. Lehninger: Principles of Biochemistry (2017) by Nelson and Cox Seventh edition. W H Freeman.
2. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. Eighth Edition. W H Freeman.
3. Outlines of Biochemistry (1987) by Conn and Stumpf. Fifth edition, Wiley, New Delhi

Clinical Biochemistry

Unit-I:	**INTRODUCTION** **(08 Lectures)** The need of clinical biochemistry, biochemical tests (general examples), importance of automation in a clinical laboratory, auto analyzers and its types, sterilization, need for sterilization, methods of sterilization, dry heat sterilization, wet heat sterilization, an introduction to autoclaving, working of an autoclave (diagrammatic) biological specimen collection, types of biological specimens, precautions during collection of biological specimens, general precautions in a clinical biochemistry lab, definition of precision and accuracy, what is quality control, need for quality control, internal and external quality control.
Unit-II:	**HEPATIC AND RENAL DISEASES** **(07 Lectures)** General discussion on the role of liver in a living organism. Liver Diseases: Cirrhosis: causes, signs and symptoms. Alcoholism and liver cirrhosis. Case studies. Hepatocellular carcinoma: causes, signs and symptoms. Case studies. Hepatitis: Viral Types, causes, signs and symptoms. Acute and chronic infection, differences. Case studies. Fatty liver disease: causes, signs and symptoms. Case studies. General discussion of the role of kidneys in a living organism. Renal Diseases: Renal infections: causes, signs and symptoms, Renal failure: causes, signs and symptoms. Case studies. Liver Function Test, Renal Function Test: Need for liver function and renal function test, understanding the markers and normal ranges of liver and renal function tests.
Unit-III:	**CARDIAC DISEASES** **(07 Lectures)** Gross structure of the heart, the four chambers and their valves, flow of blood in the heart. Angina pectoris: Causes, signs and symptoms. Myocardial Infraction: Causes, signs and symptoms, Ischemia Reperfusion injury: role of reactive oxygen species, Cardiac Arrest: Causes, sign and symptoms, Lipid Profile: Need for a lipid profile, markers of lipid profile and its normal ranges, Biochemical Markers of Myocardial Infraction: Cardiac Troponin, Lactate dehydogenase, Myoglobin.
Unit - IV:	**DIABETES MELLITUS AND BLOOD GLUCOSE** **(08 Lectures)** General discussion on diabetes mellitus, Types of diabetes mellitus (Type I, II, Gestational), Insulin- structure, biochemical role, secretion from the pancreas, ultra structure of Islet of Langerhans, alpha, beta, gamma cells, role of glucagon, blood glucose, variation in blood glucose levels, fasting and post prandial blood glucose levels – normal and diabetic ranges, Glucose Tolerance Test: procedure and significance. HbA1C, glycation of hemoglobin, clinical significance of HbA1c testing, normal ranges of HbA1c

Books Recommended:

1. Tietz Fundamentals of Clinical Chemistry (2001), 5th Ed. Burtis, C. A., Ashwood, E. R., W. B. Saunders Company, ISBN: 0-7216-8634-6
2. Harper's Illustrated Biochemistry (2015) by Rodwell, Weil, Botham, Bender, Connolly, 13th Ed. MacGraw Hill Education

Biochemical Pathways

Unit-I:	**CARBOHYDRATE METABOLISM-I (ANAEROBIC)** **(15 Lectures)** Glycolysis, alcoholic and lactic acid fermentation; gluconeogenesis; Cori cycle; Pentose phosphate pathway and its significance; glycogenolysis & glycogenesis and its regulation; Disorders associated with defects in carbohydrate metabolism- a brief account on, Diabetes Mellitus (NIDDM and IDDM), galactosemia and lactose intolerance.
Unit-II:	**CARBOHYDRATE METABOLISM-II (AEROBIC)** **(15 Lectures)** Kreb cycle individual steps and regulation, linking reaction of glycolysis and Kreb cycle, Anaplerotic reactions of Kreb cycle, Amphibolic nature of the cycle; Components, properties and function of electron transport system; chemiosmotic hypothesis and oxidative phosphorylation, inhibitors and uncouplers of the electron transport system, Shuttle systems
Unit-III:	**LIPID METABOLSIM** **(15 Lectures)** Mobilization of triglycerides, β-oxidation of saturated, monounsaturated and poly-unsaturated fatty acids, even and odd chain fatty acids. Ketogenesis and significance. Fatty acid biosynthsesis and regulation Cholesterol synthesis. Lipoprotein profile and hypercholesterolemia.
Unit-IV:	**NITROGEN METABOLISM** **(15 Lectures)** Protein catabolism-Transamination and deamination, glucogenic and ketogenic amino acids, amino acid derivatives and their biological significance; Urea cycle; Purine and pyrimidine nucleotides: biosynthesis and its regulation, Catabolism of purine and pyrimidine nucleotides.

Books Recommended:

1. Lehninger: Principles of Biochemistry (2017) by Nelson and Cox Seventh edition. W H Freeman.
2. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. Eighth Edition. W H Freeman.
3. Outlines of Biochemistry (1987) by Conn and Stumpf. Fifth edition, Wiley, New Delhi

Medical Biochemistry

Unit-I:	**INTRODUCTION** **(15 Lectures)** The need of a clinical biochemistry laboratory. Why are clinical biochemistry tests needed. What is clinical correlation and its importance. What is automation, importance of automation in a clinical laboratory, understanding automated and semi automated sterilizers, sterilization: definition and need, types of sterilization, dry heat sterilization, wet heat sterilization, autoclave diagram and working. Types of biological specimens, biological specimen collection, precautions to be taken in a clinical biochemistry lab, understanding quality control, differences between internal and external quality control.
Unit-II:	**HEPATIC AND RENAL DISEASES** **(15 Lectures)** Gross structure of the liver, general discussion of the role of liver in the organism. Liver Diseases: Liver Cirrhosis: General discussion on progression of liver cirrhosis, alcohol consumption and liver cirrhosis. Signs and symptoms. Basic treatment strategy. Fatty liver disease: General discussion on progression of fatty liver disease, role of diet in the progression of fatty liver disease. Signs and symptoms. Basic treatment strategy. Gross structure of the kidney, general discussion on the role of kidneys in an organism. Renal Failure: General discussion on progression of renal failure, causes of kidney failure. Signs and symptoms. Basic treatment strategy. Tests used for determining the functioning of the Liver and Kidneys: LFT and RFT. Molecular Markers and Normal ranges.
Unit-III:	**CARDIAC DISEASES** **(15 Lectures)** Gross structure of the heart, the four chambers and their valves, flow of blood in the heart. Systemic circulation and pulmonary circulation. Valves and arteries/veins. Angina pectoris: Causes, signs and symptoms. Myocardial Infarction: Causes, signs and symptoms, Ischemia Reperfusion injury: role of reactive oxygen species, Cardiac Arrest: Causes, sign and symptoms, Lipid Profile: Need for a lipid profile, markers of lipid profile and its normal ranges, Biochemical Markers of Myocardial Infarction: Cardiac Troponin, Lactate dehydogenase, Myoglobin.
Unit-IV:	**DIABETES MELLITUS AND BLOOD GLUCOSE** **(15 Lectures)** Diabetes Mellitus: General Introduction, types of diabetes mellitus (Type I, II, Gestational), role of diet and exercise, obesity and diabetes. Insulin- structure, biochemical role, secretion, Pancreas: ultra structure of islets of Langerhans, alpha, beta and gamma cells. Insulin and glucagon (descriptive mode of action).Variation in blood glucose, fasting and post prandial-normal ranges and diabetic ranges, variation in men and women. Glucose Tolerance Test: Procedure and interpretation. HbA1c, Glycation: general introduction, glycation and enzymatic glycosylation. Glycation of hemoglobin, HbA1c as a marker of diabetes, significance of HbA1c, HbA1c in prediabetic and diabetic state.

Books Recommended:

1. Tietz Fundamentals of Clinical Chemistry (2001), 5th Ed. Burtis, C.A., Ashwood, E. R., W. B. Saunders Company, ISBN: 0-7216-8634-6
2. Harper's Illustrated Biochemistry (2015) by Rodwell, Weil, Botham, Bender, Connolly, 13th Ed. MacGraw Hill Education

Concepts of Immunology

Unit-I:	**BASIC ASPECTS OF IMMUNITY** **(15 Lectures)** Primary and secondary lymphatic organs, spleen, thymus, lymph nodes. Innate and adaptive immunity; cellular and humoral immunity. Definition of antigen, antibody, hapten, structure of antibody molecules, classes of antibodies, isotypes, allotypes, and idiotype.
Unit-II:	**CELLS AND IMMUNE RESPONSE** **(15 Lectures)** Primary and secondary immune response. General properties of B, T, NK, NKT cells, types of T cells. Tolerance, B and T cell tolerance.
Unit-III:	**HYPERSENSTIVITY** **(15 Lectures)** Hypersensitivity. Type I, II, III and IV hypersensitivity; the allergic response and its causes, Immunoglobulin E, mast cells reactions of delayed hypersensitivity.
Unit-IV:	**IMMUNO-TECHNIQUES AND VACCINES** **(15 Lectures)** Monoclonal and polyclonal antibodies- Principle, technique, production and applications. Vaccine-Types, advantages and disadvantages. ELISA, ELISPOT and FACS.

Books Recommended:

1. The Elements of Immunology (2s012) by Fahim H. Khan.-2nd Imp, Pearson Education Inc.
2. Kuby's Immunology (2013) by Richard A. Goldsby, Thomas J. Kindt and Barbera A. Obsorne. 7th edition, Freeman Press, New York.
3. Microbiology by B. D. Davis, R. Dalbacco H. S. Ginsberg, W. B. Wood & M. Mclanty (Harper & Row Publishers) 3rd Edition.
4. Immunology (2015) by I. Roit J. BrosTaft and Male.13thedition Mos by Publishers.

Proteins

Unit-I:	**GENERAL PROPERTIES OF PROTEINS AND AMINO ACIDS** **(15 Lectures)** General properties of amino acids, peptide bonds, biologically active peptides. Primary structure of proteins and its significance. Strategies of sequence determination–amino acid composition, determination of N- and C- terminal residues; chemical and enzymatic degradation of polypeptides, automated sequenators. Chemical synthesis of peptides (Merrifield method). Peptide mapping, disulphide bonds in proteins and their significance. Chemical cross-linking of proteins. Selenocysteine.
Unit-II:	**PROTEIN STRUCTURE AND ANALYSIS** **(15 Lectures)** Dihedral angles and Ramachandran plot. Secondary structure of proteins: alpha helix, beta structure, beta turn, beta barrel. Alpha keratin and collagen helix, dinucleotide fold. Tertiary and quaternary structure of proteins; forces stabilizing the structure of proteins. Denaturation and renaturation of proteins: Anfinsen experiment on RNase A. Multimer, oligomer, protomer, molten globules. Prediction of 2° and 3° structure from knowledge of primary structure; Techniques used in determining protein structure - CD, NMR and X-ray. Hydrophobicity plots; Stokes radius and intrinsic viscosity of proteins.
Unit-III:	**PROTEIN DOMAINS AND HEME PROTEINS** **(15 Lectures)** Protein domains and motifs; DNA binding proteins motifs: helix turn helix, zinc finger, homeodomain, leucine zippers, Ca++ binding proteins; helix loop helix, hairpin β-motif and β-α-β motifs. Structure and function of the oxygen binding proteins: hemoglobin and myoglobin: Hill's plot, Bohr's effect, sickle cell anemia, thalassemia, neuroglobin.
Unit-IV:	**PROTEIN FOLDING AND MISFOLDING** **(15 Lectures)** Spontaneous and assisted protein folding, folding funnel, role of chaperones and chaperonins in protein folding of prokaryotes and eukaryotes; protein disulphide isomerase and protein prolyl isomerase, clinical significance of secondary structure, amyloid fibrils, prions, Diseases caused by protein misfolding, Alzheimer's, Parkinson's, Huntington's, Amyotrophic lateral sclerosis.

Books Recommended:

1. Lehninger: Principles of Biochemistry (2017) by Nelson and Cox. Seventh edition, WH Freeman and Co.
2. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. Eighth Edition, WH Freeman and Co.
3. Biochemistry (1998) by GL Zubay. Fourth edition, WC Brown Publishers, USA.

Biochemical Techniques

Unit-I:	**SPECTROSCOPIC TECHNIQUES** **(15 Lectures)** Different types of spectra (excitation and emission spectra) and their biochemical usefulness; Beer Lamberts law; Types of spectroscopy: atomic and molecular spectroscopy; Principle and instrumentation of colorimeter, UV-visible and fluorescence spectrometer, atomic absorption spectroscopy and Fourier transform infra red spectroscopy.
Unit-II:	**CHROMATOGRAPHIC TECHNIQUES** **(15 Lectures)** Classification of chromatographic methods; basic understanding of the common chromatographic terms (analyte, mobile phase, stationary phase, eluent, eluate, elution and chromatogram); nature of stationary and mobile phase; principle, method and applications of paper chromatography, development of chromatograms (ascending, descending, radial etc), R_f values, factors affecting R_f values, general idea of 2D paper chromatography; Column chromatography- principle, instrumentation and applications; HPLC-principles, instrumentation–block diagram and applications; Ion exchange chromatography- principle, method and applications, cationic and anionic exchangers; Affinity chromatography-principle and applications.
Unit-III:	**CENTRIFUGATION AND ELECTROPHORESIS** **(15 Lectures)** Introduction to centrifugation; angular velocity, relative centrifugal force (RCF), sedimentation rate and sedimentation coefficient; types of rotors and centrifuge (low speed, high speed and ultracentrifuge); definition of analytical and preperative centrifugation; principle and application of density gradient centrifugation (rate zonal and isopycnic centrifugation), method for generation of density gradients; principle and application of differential centrifugation. Basic principles and application of agarose gel electrophoresis, polyacrylamide gel electrophoresis (PAGE), SDS-PAGE and 2D electrophoresis; factors affecting migration rate (sample, electric field, buffer and supporting medium); detection of proteins on gels (staining- general, specific, activity staining).
Unit-IV:	**IMUNOLOGICAL AND RADIOISOTOPE TECHNIQUES** **(15 Lectures)** Immunological Techniques**:** Single and double immunodiffusion; immune-lectrophoresis; radioimmunoassay (RIA); enzyme linked immunosorbent assay (ELISA); Enzyme-Linked Immunospot (ELISpot); immunofluorescence; immunoblotting and flow cytometry.

Books Recommended:

1. K. Wilson and K. H. Goulding, A. Biologist' guide to principles and techniques of practical biochemistry, (1986), ELBS/ Edward Arnold.
2. D. Friefelder, Physical biochemistry, (1992), W. H. Freeman and Co., New York.
3. T. G. Cooper, Tools of biochemistry, (1977), John Wiley and Sons, New York.
4. D. T. Plummer, An introduction to practical biochemistry, (1979), Tata McCraw Hill Publishing Co., Ltd., New Delhi.

Biochemistry of Food

Unit-I:	**INTRODUCTION TO NUTRITION** **(07 Lectures)** Functions of foods; definition of nutrition, health and diseases; adequate and optimum nutrition; malnutrition (protein energy malnutrition); Food as a source of nutrients; Inter relationship between nutrition and health; obesity and other eating disorders- bulimia and anorexia.
Unit-II:	**NUTRITIONAL REQUIREMENTS** **(08 Lectures)** Nutrition and Energy supply; Recommended dietary allowances; Basal Metabolic rate; Balanced Diet; Glycemic index; Assessment of nutritional status; Nutritional requirements of infants, pregnant women, lactating women and elderly person.
Unit-III:	**COMPONENTS OF FOOD** **(07 Lectures)** Macronutrients: Carbohydrates: functions, classification, sources, storage in body; Fats & oils: composition, classification, sources and functions; Proteins: composition, sources, essential & non-essential amino acids, functions. Micronutrients: vitamins: classification, function, sources and deficiency of Vit A, D, E, K, B and C; Minerals: function, sources, deficiency of K, Ca, Na, Mg, Fe, Cu and Zn.
Unit-IV:	**EMERGING TRENDS IN FOOD BIOCHEMISTRY** **(08 Lectures)** Nutraceuticals and functional foods; concept of free radicals and antioxidants; definition and general idea about role of probiotics, prebiotics and dietary fibres; basic idea about food fortification and genetically modified food.

Books Recommended:

1. Textbook of Biochemistry with Clinical Correlations (2011) by T M Devlin. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
2. Essentials of Clinical Nutrition (1988) by E B Feldman. Davis Company ISBN-0-8036-3431
3. Nutrition for Health, Fitness and Sport (2013); Williams. M. H, Anderson, D. E, Rawson, E. S. McGraw Hill international edition. ISBN-978-0-07-131816-7

Recombinant DNA Technology

Unit-I:	**TOOLS OF RECOMBINANT DNA TECHNOLOGY** **(15 Lectures)** Tools of recombinant DNA technology: Enzymes used in genetic engineering, e.g., Restriction endonucleases, SI nucleases, DNA ligases, Alkaline phosphatase, Reverse transcriptase, DNA polymerase, polynucleotide kinase, terminal transferase. Cloning vectors**:** General properties of ideal cloning vectors.
Unit-II:	**GENE CLONING AND CHARACTERIZATION** **(15 Lectures)** Construction of chimeric DNA molecules. Isolation of plasmid DNA, genomic DNA. Sequencing methods; Sanger's dideoxy chain termination method, Maxam Gilbert chemical degradation method.
Unit-III:	**RECOMBINANT DNA EXPRESSION AND IN VITRO DNA AMPLIFICATION** **(15 Lectures)** Expression vectors, Expression construct. Different types of expression systems. Amplification of genomic DNA and cDNA by PCR. Cloning of PCR products. Applications of PCR
Unit-IV:	**APPLICATIONS OF GENE TECHNOLOGY** **(15 Lectures)** Transgenic organisms. Regulation of GM organisms, Molecular diagnostics, high throughput methodsof DNA analysis, DNA microarrays, DNA fingerprinting and its applications, Gene therapy, and DNA vaccines.

Books Recommended:

1. Molecular cloning: A Laboratory Manual: volumes1-3 (2012) by Green and Sambrook. Fouth edition, Cold Spring Harbor Laboratory Pub.
2. Principles of Gene Manipulation and Genomics (2016) by Primrose and Twyman. Eighth edition, Wiley.

Molecular Biology

Unit-I:	**DNA REPLICATION AND TRANSCRIPTION** **(15 Lecture)** **Replication:** Possible modes of replication, Meselson-Stahl experiment, the origin of replication in E. coli, replication chemistry and major proteins and enzymes involved in the replication process; rolling circle model of replication. **Transcription:** Promotor, Transcription start and stop sites, UTRs, Coding and Non-coding strands, Mechanism of transcription DNA-dependent RNA polymerase(s), recognition, binding and initiation sites, TATA/ Pribnow box, transcription termination in prokaryotes, Post-transcriptional modifications of mRNA: Capping, Splicing, PolyA tailing, Editing; inhibitors of transcription.
Unit-II:	**GENETIC CODE AND TRANSLATION** **(15 Lecture)** **Genetic Code:** Basic features of genetic code, the biological significance of degeneracy, Wobble hypothesis, Isoaccepting tRNAs, universality of genetic code and its exceptions, Codon usage bias, single coding system between nucleic acids and amino acids. ORF: initiation and non sense codons. **Mechanism of Translation:** Ribosomes structure and function, Peptidyl transferase, tRNA structure and charging, Aminoacyl t-RNA synthetase, Initiator tRNAs, initiation in prokaryotes, Shine-Dalgarno consensus sequence, formation of 70S initiation complex, the role of EF-Tu, EFTs, EF-G, GTP and release factors (RF1 and RF2). Inhibitors of protein synthesis.
Unit-III:	**REGULATION OF GENE EXPRESSION IN PROKARYOTES** **(15 Lecture)** Principles of gene regulation, Difference between eukaryotic and prokaryotic gene regulation: negative and positive regulation, the concept of operons, regulatory proteins, activators, repressors, Effector molecules: Inducer/ Co-repressor, regulation of lac operon: Use of partial diploids in understanding lac operon regulation, trp operon, attenuation and antitermination.
Unit-IV:	**REGULATION OF GENE EXPRESSION IN EUKARYOTES** **(15 Lecture)** Heterochromatin, euchromatin, chromatin remodeling, the role of chromatin structure and post-translational modifications of histones in gene expression. DNA methylation: de novo and maintenance methylation, regulation of galactose metabolism in yeast.

Books Recommended:

1. Lehninger: Principles of Biochemistry (2017) by Nelson and Cox Seventh edition.
2. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. Eighth Edition.
3. Molecular Biology of the Gene (2017) by Watson, Hopkin, Roberts, Stertz, Weiner, Freeman Pub., San Francisco.
4. Molecular Biology: Principles of Genome Function (2010) by Nancy Craig, Orna Cohen-Fix, Rachel Green, Carol Greider, Gisela Storz and Cynthia Wolberger. Second edition, Oxford

Biosafety and Bioethics

Unit-I:	**INTRODUCTION** **(15 Lectures)** Definition of biosafety and biohazards; types of risk groups; Containment and its types (physical and biological); types of physical containments (primary, secondary and tertiary); components of primary containment (HEPA filters, laminar flow, fume hoods, PPE etc); introduction to biological safety cabinets, biosafety levels of specific microorganisms, recommended biosafety levels for infectious agents and infected animals.
Unit-II:	**BIOSAFETY GUIDELINES** **(15 Lectures)** Definition of genetically modified organisms (GMOs) and living modified organisms (LMOs); roles of different committees like rDNA advisory committee (RDAC, institutional biosafety committee (IBSC), review committee on genetic manipulation (RCGM), genetic engineering approval committee (GEAC) for GMO applications in food and agriculture; harmful impact of environmental release of GMOs; biosafety assessment of pharmaceutical products such as drugs/vaccines etc.
Unit-III:	**FOUNDATION OF BIOETHICS** **(15 Lectures)** Bioethics-Definition; historic evolution; environmentally responsible use of biotechnology; ethical implications of biotechnological products and techniques; definition, social and ethical implications of biological weapons; ethical use of animals in the laboratory.
Unit-IV:	**CODES, COVENANTS, DECLARATIONS AND GUIDELINES** **(15 Lectures)** Bioethics in relation to profession, society, and biomedicine; gradation of moral and ethical norms from simpler to higher levels for initiating right actions (Kohlberg's theory of moral development); major codes, guidelines and universal principles of bioethics.

Books Recommended:

1. Bioethics and Biosafety (2008) by M. K Sateesh. First edition, IK International Pvt Ltd. ISBN-13: 978- 8190675703.
2. The Cambridge Textbook of Bioethics (2008), Peter A. Singer and A. M. Viens. First edition, Cambridge University Press, ISBN-13: 978-0511545566.
3. Foundation of Bioethics (1996) by EH Tristram. Second edition, Oxford University Press, ISBN-13: 9780195057362.
4. Principles of Biomedical Ethics (2011) by T Beauchamp and JF Childress. Sixth edition, Oxford University Press, 2001. ISBN-13: 978-0195143317.
5. Genetically Modified Organisms and Biosafety (2004) by Tomme Young. First edition. ISBN-13: 978- 2831707983.

Basic Research Methodology

Unit-I	Research and work ethics, research interest, importance of time. Aims, objectives, meaning and significance of scientific research. *In silico, in vitro, in vivo* and *ex-vivo* experiments. **(7 Lectures)**
Unit-II	Concept of concentration (molality, molarity, percentage, W/V, V/V), dilution, stock solution, working solution. Protocols for a few biological reactions and unit conversion. Concept of central tendency of dataset using mean, median & mode. . **(8 Lectures)**
Unit-III	Commonly used equipment and their applications: Centrifuges, colorimeter, chromatography columns, distillation apparatus, incubators, laminar flow, microtome, pH meter, shakers, spectrophotometer, spectrofluorometer, light microscopes, electron microscopes (TEM, SEM), PCR machine, electrophoresis apparatus for nucleic acids and proteins. **(9 Lectures)**
Unit-IV	Literature survey on PubMed. Types of research papers: research article, research communication/letter and reviews. Writing of scientific reports. **(6 Lectures)**

Books Recommended/Suggested Readings:

1. Guide to research: Jeff Lenburg, Publisher: Viva Books.
2. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
3. Writing 'How to' Articles & Books: Chriss McCallum, Publisher: GLMP Ltd.
4. Statistics for Biologists, Campbell, R.C., 1998.Cambridge University Press.

Advanced Enzymology

Unit-I:	**NATURE AND KINETICS OF ENZYME CATALYZED REACTIONS** **(15 Lectures)** Review of uni-substrate enzyme kinetics and factors affecting the rates of enzyme catalyzed reactions. Methods of examining enzyme-substrate complexes; flexibility and conformational mobility of enzymes. Mapping of active site; affinity labeling and chemical modification methods of active site determination.
Unit-II:	**KINETICS AND MECHANISMS OF MULTISUBSTRATE REACTIONS** **(15 Lectures)** Classification of multi-substrate reactions with examples of each class; kinetics of multi-substrate reactions; Derivation of the rate of expression for ping-pong, compulsory, random ordered bi-bi reaction mechanism and Theorell-Chance bi-bi reactions by using alcohol dehydrogenase enzyme as an example; use of initial velocity, inhibition and exchange studies to differentiate between multi-substrate reaction mechanisms.
Unit-III:	**MECHANISM OF ENZYME ACTION** **(15 Lectures)** Detailed mechanism of catalysis of chymotrypsin and triose phosphate isomerase. Concept of convergent and divergent evolution of enzymes citing examples of serine proteases. Polygenic nature of multienzyme systems. Mechanism of action and regulation of pyruvate dehydrogenase complex.
Unit-IV:	**ENZYME REGULATION** **(15 Lectures)** General mechanisms of enzyme regulation; control of enzyme activity by products and substrates; control by zymogen formation. Regulation of enzyme activity by proteins. Allosteric enzymes; structure and functions of ATCase; cooperative binding, homotropic and heterotropic interactions, Hill equation and Hill plot, sigmoidicity of the substrate–velocity curve. Concerted and sequential models for action of allosteric enzymes and their significance.

Books Recommended:

1. Fundamentals of Enzymology (1999) by Price & Stevens.
2. Structure and Mechanism in Protein Science; Guide to Enzyme Catalysis (1999) by A. Fersht. Freeman Press.
3. Enzymes; Biochemistry, Biotechnology, Clinical Chemistry (2001) by T. Palmer. Horwood Ltd.
4. Molecular Enzymology (1981) by CW Wharton and R Eisenthal. Wiley
5. Biochemical Calculations (1976) by I.H. Segal. John Wiley & Sons.
6. Understanding Enzymes (1985) by T. Palmer. Ellis Horwood Ltd.

Classical and Modern Genetics

Unit-I:	**CLASSICAL GENETICS** **(15 Lectures)** Molecular basis of evolution; An overview of classical and modern genetics; Forward and reverse genetic approaches; Mendelian genetics–Laws of inheritance, Deviation from Mendelian inheritance: Incomplete dominance, co-dominance, Epistasis, pleiotropy, polygenic inheritance, genomic imprinting, Extranuclear inheritance etc.
Unit-II:	**BACTERIAL GENETICS** **(15 Lectures)** Genotypic and phenotypic variations in bacteria. Detection, selection, and isolation of mutants. Evidence for Spontaneous Mutations-Luria-Delbrück Fluctuation Test; Mechanism of gene transfer in bacteria: horizontal & Vertical Gene Transfer. Transformation, Transduction, and conjugation- their use in gene mapping.
Unit-III:	**VIRAL AND YEAST GENETICS** **(15 Lectures)** Viral variations: Mutations, and recombination. Fine structure mapping of rII system of T4 phage with special reference to Benzer's experiment, complementation test. Basic features of *S. cerevisiae* and *N. crassa* genetics: sexual and asexual cycles; Beadle and Tatum experiment on Neurospora, Mating type switching in *S. cerevisiae:* Structure of MAT locus, and Proteins involved in mating types switch
Unit-IV:	**EPIGENETICS** **(15 Lectures)** Introduction: Genetics vs. Epigenetics; Overview of molecular mechanisms of epigenetic regulation: DNA methylation and Histone modifications and Histone variants, Non-coding RNAs. Examples of epigenetic regulation: Mono-allelic expression, dosage compensation, genomic imprinting, epigenetic reprogramming during germline/embryonic development and tissue regeneration, Epigenetic dysregulation, and human diseases. Overview of experimental technologies to study the epigenome.

Books Recommended:

1. Fundamentals of Biochemistry: Life at the Molecular Level (2016) by Voet, Voet and Pratt. Fifth edition, John Wiley & Sons, N.Y.
2. Molecular Biology of the Gene (2017) by Watson, Hopkin, Roberts, Stertz, Weiner, Freeman Pub., San Francisco.
3. Lewin's Genes XII (2017) by Krebs, Goldstein, Kilpatric. Oxford University Press, London.
4. Fundamentals of Genetics by Gardner and Snustad.
5. Epigenetics by C David Allis, Marie-Laure Caparros, and others (Text book)

Molecular Basis of Non-Infectious Diseases

Unit-I:	**NUTRITIONAL DISORDERS** **(15 Lectures)** Overview of major and minor nutrient components in the diet. Balanced diet and the concept of RDA. Nutrient deficiencies; Kwashiorkor and Marasmus, scurvy, beri beri, pellagra and vitamin B12 deficiency, Xerophthalmia and night blindness, vitamin A deficiency, vitamin K deficiency; their symptoms.
Unit-II:	**METABOLIC AND LIFE STYLE DISORDERS** **(15 Lectures)** Obesity and eating disorders like anorexia nervosa and bulimia. Diabetes mellitus as metabolic syndrome and the relationship with hypertension, obesity, hypothyroidism and stress. Cardiovascular disorders and atherosclerosis-defining the ailments that fall in this category, understanding the factors that contribute to the syndrome. Irritable bowel syndrome- influence of diet, stress and environment on the condition.
Unit-III:	**MULTIFACTORIAL COMPLEX DISORDERS AND CANCER** **(15 Lectures)** Understanding the definition of multifactorial diseases. Polygenic diseases and the relationship of environmental factors and genetic makeup in the onset of diseases. Cancer: characteristics of a transformed cell, stages of cancer, proto-oncogenes and tumour suppressor genes; Disorders of mood: Schizophrenia, dementia and anxiety disorders. Polycystic ovarian syndrome, ALS.
Unit-IV:	**MONOGENIC DISEASES AND DISEASES DUE TO MISFOLDED PROTEINS** **(15 Lectures)** In born errors of metabolism: PKU, alkaptonuria, maple syrup urine disease. Receptor and transport defects: cystic fibrosis, long QT syndrome, familial hypercholesterolemia, Achondroplasia. Hemoglobinopathies and clotting disorders. Etiology and molecular basis for Alzheimer's and prion diseases, Huntington's chorea, sickle cell anaemia, thalassemia.

Books Recommended:

1. Textbook of Biochemistry with Clinical Correlations (2011) by T M Devlin. John Wiley & Sons, Inc. (NewYork), ISBN: 978-0-4710-28173-4.
2. Introduction to Human Physiology (2013) Lauralee Sherwood. Eighth edition, Brooks/Cole, Cengage Learning.
3. The World of the Cell (2009) by Becker, Klinesmith, Hardin, Bertoni. Seventh edition, Pearson.
4. Genetics (2012) by Snustad and Simmons. Sixth edition, John Wiley.
5. The Cell: A Molecular Approach (2015) by Cooper and Hausman. Seventh edition, Sinauer Associates, MA.

Concepts of Human Physiology

Unit-I:	**BLOOD AND CIRCULATORY SYSTEM** **(15 Lectures)** Formed elements of blood: Physiology and biochemistry, kinetics, function, and lifespan; hematopoiesis: abnormalities. Hemostasis & thrombosis: Structure-function relationships of factors/proteins, pathways involved in hemostasis: abnormalities. Anti-clotting mechanisms, anticoagulants. Antigen systems in red cells, platelets and leukocytes and their implications in transfusion. Structure of the heart, different phases of the cardiac cycle, heart sounds, and ECG.
Unit-II:	**RENAL PHYSIOLOGY** **(15 Lectures)** Physiologic anatomy of the kidney; urine formation, glomerular filtration, tubular reabsorption, Tubular secretion, determinants of the GFR, renal blood flow, physiologic control of glomerular filtration and renal blood flow. Renal tubular reabsorption and secretion, passive and active mechanisms of reabsorption, secretion along different parts of the nephron, renal control of acid-base balance, quantifying renal acid- base Excretion.
Unit-III:	**ENDOCRINE AND DIGESTIVE SYSTEM** **(15 Lectures)** a) Endocrine System: Role and function of various endocrine glands and their hormones. Mechanisms of action of hormones. Hormone secretion, transport, and clearance from the blood. b) Digestive system: Structure and functions of different components of digestive system; Digestion of the various foods by hydrolysis, basic principles of gastro-intestinal absorption, Absorption in the small intestine. Absorption in the large intestine: Formation of faeces. Mechanism of HCl formation in stomach; role of bile salts in lipid digestion and absorption.
Unit-IV:	**RESPIRATORY SYSTEM** **(15 Lectures)** Organization of respiratory system. Exchange of gases, transport of oxygen: Mechanics of Pulmonary ventilation, alveolar ventilation, Diffusion of gases through the respiratory membrane, Chemical control of respiration, and transport of CO_2: Bohr's effect, isohydric transport of CO_2 and chloride shift. Acid-base balance: acidosis and alkalosis, the role of lung and kidney in regulating acid-base balance**.**

Books Recommended:

1. A Text Book of Animal Physiology (2008) by A K Berry. Eleventh edition, Emkay Publications, New Delhi
2. Guyton and Hall Textbook of Medical Physiology (2015) by J E Hall.13th edition, W B Saunders Co., USA
3. Principles of Biochemistry: Mammalian Biochemistry (1985) by E L Smith, R L Hill, I R Lehman, R J Lefkowitz, P Handler, A White. Seventh edition, Tata McGraw Hill International Book Co.

Molecular Cell Biology

Unit-I:	**CELLS AND SUBCELLULAR ORGANELLES** **(15 Lectures)** Structural organization of eukaryotic and prokaryotic cells. Ultrastructure of nucleus (nuclear envelope, nucleolus, nucleosome and chromatin packaging), mitochondria (ultrastructure organization of the electron transport chain components and oxidative phosphorylation), endoplasmic reticulum (smooth and rough), vectorial discharge, Golgi apparatus (role in secretion, coated vesicles). Role of ER and GA in synthesis of membrane proteins; protein glycosylation, post-translational modifications, sorting, maturation and secretion of proteins. Lysosomes (primary and secondary lysosomes and their functions), peroxisomes, vacuoles and microbodies.
Unit-II:	**BIOMEMBRANES AND TRANSPORT** **(15 Lectures)** Molecular constituents, physico-chemical properties, supramolecular structure, organization and architecture (fluid mosaic model) of biomembranes. Asymmetric organization of lipids and proteins in biological membranes. Specialized regions of the plasma membrane. Detailed structure of human erythrocyte membrane. Liposomes as model membranes and their applications in biology and medicine. Transport across biological membranes: Simple diffusion, facilitated diffusion, and active transport. Transport ATPases. Detailed mechanism of action of Na- K-ATPase. Transport via vesicle formation. Endocytosis, exocytosis and phagocytosis, receptor-mediated endocytosis of LDL and familial hypercholesterolemia.
Unit-III:	**EPITHELIA AND EXTRACELLULAR MATRIX** **(15 Lectures)** Types of tissues, microvilli, epitheliumtypes of epithelial apices and glycocalyx matrix. Specialized regions of biological membranes and types of cell junctions. Structural features and characteristics of the basement membrane. Extracellular matrix-collagen, elastin, fibrillin, fibronectin, laminin and proteoglycans.
Unit-IV:	**CYTOSKELETON** **(15 Lectures)** Self-assembly and dynamic structure of cytoskeletal filaments, motor proteins associated with microtubules, and their role in intra-cellular transport. Labile and semi-permanent structures (cilia and flagella). Structure and organization of actin and myosin in the muscle; muscle contraction and relaxation mechanism. Role of calcium and calmodulin in muscle contraction

Books Recommended:

1. Molecular Biology of the Cell (2014) by Bruce Alberts. Sixth Edition
2. Molecular Cell Biology (2016) by Lodish, Berk, Kaiser, Krieger, Bretscher. 8th Edition, W H Freeman & Co Ltd
3. Lewin's Genes XII (2017) by Krebs, Goldstein and Kilpatric. Oxford University Press, London.
4. Lehninger: Principles of Biochemistry (2017) by Nelson and Cox. Seventh edition. W H Freeman and Co.
5. Biochemistry (2015) by Berg, Tymoczko, Gatto, Stryer. Eighth edition, W H Freeman and Co.

Plant Biochemistry

Unit-I:	**PLANT CELL WALL AND CELL MEMBRANE** **(08 Lectures)** Structure and function of plant cell including cell wall, plasmodesmata, peroxisomes, meristematic cells, vacuoles, secretary systems and pathways: endoplasmic reticulum & Golgi apparatus, chloroplast and mitochondria.
Unit-II:	**PHOTOSYNTHESIS** **(07 Lectures)** Light harvesting complexes, dark reactions of photosynthesis. Regulation of photosynthesis in higher plants, phytorespiration. C3, C4 and CAM metabolism. Origin of chloroplast and mitochondria (endosymbiont hypothesis).
Unit-III:	**NITROGEN FIXATION AND SECONDARY PLANT METABOLISM** **(08 Lectures)** Biological nitrogen fixation and reduction of nitrate to ammonia, nitrate assimilation as globins, prolamins and triacylglycerols. Sulfate assimilation, 2S proteins. Translocation of inorganic and organic substances, aquaporins, Ion channels.
Unit-IV:	**PLANT HORMONES AND DEVELOPMENT** **(07 Lectures)** Plant hormones - growth regulating substances and their mode of action. Molecular effects of auxins in regulation of cell extension and of gibberlic, abscisic acids and cytokinins in the regulation of seed dormancy and germination. Steriod and peptide hormones, Response of plants to pathogens and herbivores as secretins: tannins and signals: phtoalexins, salicylic acid and jasmonates, Applications and examples of transgenic plants.

Books Recommended:

1. Introduction to Plant Biochemistry (1990) by TW Goodwin and EI Mercer. Second edition, Pergaman Press.
2. Plant Biochemistry (1997) by PM Dey and JB Harborne. First edition, Academic Press.
3. Handbook of Photosynthesis (ed) Mohammad Pe Sarakle, Marcel Dekkar.

Molecular Basis of Infectious Diseases

Unit-I:	**CLASSIFICATION OF INFECTIOUS AGENTS** **(15 Lectures)** Past and present, emerging and re-emerging infectious diseases and pathogens, factors responsible for re-emergence. Concept of infection and evasion. Source, reservoir and transmission of pathogens. Antigenic shift and antigenic drift. Overview of viral and bacterial pathogenesis. Infection and evasion.
Unit-II:	**OVERVIEW OF DISEASES CAUSED BY BACTERIA** **(15 Lectures)** Study of important bacterial diseases- Tuberculosis, typhoid, diphtheria, pertussis, tetanus, pneumonia, food poisoning, lyme disease. Causative agent, molecular basis of infection and pathogenicity. Therapeutics, and vaccines. Drug resistance and implications for public health.
Unit-III:	**OVERVIEW OF DISEASES CAUSED BY VIRUSES** **(15 Lectures)** Study, causative agent, pathogenesis, diagnostics, drugs of hepatitis, influenza, rabies, chikungunya, polio, COVID-19 and H1N1.
Unit-IV:	**OVERVIEW OF DISEASES CAUSED BY PROTOZOA AND OTHER PARASITES** **(15 Lectures)** Study of malaria- vectors, life cycle, diagnostics, drugs. Brief study of trypanosomiasis, leishmaniasis, amoebiasis

Books Recommended:

1. Prescott, Harley, Klein's Microbiology (2008) by JM Willey, L Sherwood, CJ Woolverton. Seventh edition, Graw Hill International Edition (New York).
2. Mandell, Douglas and Bennett. S, Principles and Practices of Infectious diseases,7th edition, Volume, 2. Churchill Livingstone Elsevier.
3. Sherris Medical Microbiology: An Introduction to Infectious Diseases by Kenneth J. Ryan, C. George Ray, Publisher: McGraw-Hill.
4. Medical Microbiology by Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller, Elsevier Health Sciences.