MOUNT CARMEL COLLEGE, AUTONOMOUS

No. 58, Palace Road, Bengaluru, India - 560 052

Syllabus for M. Sc. Biochemistry

Choice Based Credit System (CBCS)

2020 – 2022

M.Sc. Biochemistry Syllabus (2020-2022)

Semester I		Credits
CC – 01	Biomolecules (General Biochemistry Practicals)	5
CC – 02	Microbiology (Microbiology Practicals)	5
CC – 03	Metabolism I (Food Biochemistry Practicals)	5
CC – 04	Human Physiology (Biochemical Calculations)	5
AC – 01	Basic Biostatistics	2
AC – 02	Organic chemistry	2
Semester II		
CC – 05	Biochemical Techniques (Biochemical Techniques Practicals)	5
CC – 06	Nutritional and Clinical Biochemistry (Clinical Biochemistry Practicals)	5
CC – 07	Metabolism – II (Enzymology Practicals)	5
CC – 08	Enzymology (Hormone Chemistry)	5
AC – 03	Research Methodology	2
AC – 04	Biochemical Toxicology	2
Semester III		
EC – 01	Immunology (Immunology Practicals)	5
EC – 02	Plant Biochemistry / Neurochemistry (Fractionation Techniques Practicals)	5
EC – 03	Cell and Membrane Biology / Molecular Endocrinology (Protein Chemistry Practicals)	5
EC – 04	Molecular Biology – I (Cancer Biology)	5
AC – 05	Bioinformatics	1
OC– 01	Lifestyle disorders	1
Semester IV		
EC – 05	Molecular Biology – II (Molecular Biology Practicals)	5
EC – 06	Molecular Pharmacology/Biotechnology (Nanobiotechnology)	4
EC – 07	Biochemical Genetics/ Human Genetic disorders	4
PR- 01	Project	8

M.Sc. Biochemistry

Program outcomes

PO1: Be able to demonstrate an understanding of fundamental biochemical principles, such as the structure/function of biomolecules, metabolic pathways, and the regulation of biological/biochemical processes

PO2: Be able to employ critical thinking and scientific inquiry in the performance, design, interpretation and documentation of laboratory experiments

PO3: To Communicate the concepts and results of their laboratory experiments through effective writing and/or oral communication using the discipline standards for reporting and citation

PO4: To analyze critically and evaluate constructively the concept of science and effectively bring out the knowledge derived from that

PO5: To gain insight into the most significant molecular and cell-based methods used today to expand our understanding of biology

PO6: To Communicate the concepts and results of their laboratory experiments through effective writing and/or oral communication using the discipline standards for reporting and citation.

PO7: Be able to integrate knowledge learned in discipline specific courses

I semester

CC 01: Biomolecules 45 hrs

Objectives

- *To identify and study the basic chemistry of biomolecules*
- *To recognize the connection between structure, functions and properties of biomolecules*
- *To understand how biomolecules are engineered and are used in living systems*

Course Outcomes

CO1: Ability to demonstrate foundational knowledge of chemistry in biomolecules.
CO2: Ability to outline and exemplify the relation between structure and function of biomolecules.
CO3: Ability to analyze the potential of biomolecules that can solve major issues at the forefront of the discipline.
CO4: Ability to extend knowledge on the role of biomolecules for a better understanding of molecular biology tools.

Carbohydrates: Discovery and historical aspects, classification, configurational and conformational aspects of carbohydrates. Structure, properties and functions of homo and hetero-polysaccharides. Blood groups and bacterial polysaccharides. Glycoproteins, Cardioglycosides. 9 hrs

Lipids: Discovery and historical aspects, classification and types of lipids. Structure and properties of fatty acids, acyl glycerols, phospholipids, sphingolipids, glycolipids. Structure and function of steroids, prostaglandins, thromboxanes and leukotrienes. Composition and biological role of lipoproteins. 10 hrs

Amino acids and Proteins: Discovery and historical aspects, acid-base properties of amino acids. Non-protein amino acids. Peptide bond- structure and conformation. Biologically active peptides. Peptide synthesis – reactive ester method and modified Merrifield solid phase synthesis. Elucidation of primary structure of proteins. Secondary structure – α-helix, β-sheet, triple helical structure. Ramachandran plot. Structure of Insulin, Ribonuclease, Lysozyme, Myoglobin and Chymotrypsin. Quaternary structure – Hemoglobin. Protein denaturation. Protein folding. Role of heat shock proteins. Structure-function relationship: Hair, Silk. Prions. 13 hrs

Nucleic acids: Discovery and historical aspects, structure of nitrogenous bases, nucleosides, nucleotides. Nature of genetic material and experimental proof. Isolation, fractionation and characterization of nucleic acids. Double helical structure of DNA, polymorphism of DNA (A,

B, Z forms), supercoiling of the DNA molecule; topoisomers and superhelices, higher orders of DNA structure - Chromatin Structure, histones and nucleosomes. Re-association kinetics, repetitive DNA sequences: tandem repeats (Satellites, minisatellites, and microsatellites), interspersed repeats (LINE, SINEs), single copy genes. RNA structure: Types of RNA, structure of mRNA, tRNA, SiRNA, microRNA with emphasis on importance of structure to its function. Chemical synthesis of oligonucleotide. Nucleic acid sequencing – rapid sequencing methods.

13 hrs

References

1. Lehninger Principles of Biochemistry 4th Edn by David L. Nelson and Michael M. Cox, WH Freeman and Company.
2. Principles of Biochemistry by Geoffrey Zubay. McGraw Hill Publishers.
3. Biochemistry by Lubert Stryer. WH Freeman and Co.
4. Biochemistry and Molecular biology by William H. Elliott and Daphne C. Elliott. Oxford University Press.
5. Biochemistry 3rd Edn. by Donald J. Voet and Judith G. Voet. John Wiley and Sons.
6. Principles of Biochemistry by Robert Horton, Laurence A Moran, Gray Scrimgeour, Marc Perry and David Rawn. Pearson Education.
7. Nucleic acid Biochemistry and Molecular Biology, Mainwaring et al., Blackwell
8. Scientific (1982) Principles of Protein Structure, Function, & evolution, Dickerson & Geis 2nd Edn.
9. Benjamin-Cummings Physical Biology of the Cell, 2nd Edn. Rob Phillips, Jane Kondev, Julie Theriot, Hernan Garcia, Garland Publishers.
10. Principles of Biochemistry; Smith et al., McGarw Hill.

CC 02: Microbiology 45 hrs

Objectives

- *To understand the structural and functional properties of different microbes*
- *To study the industrially important microbes and their role in product formulations in food, pharmaceutical, beverage industry*

Course outcomes

CO1: Ability to compare and contrast the structures of cell membranes and cell walls in different microbes.

CO2: Ability to apply microbiological concepts and basic research findings.

CO3: Ability to cite examples of the vital role of microorganisms in product formulations in food, pharmaceutical, beverage and other industries.

CO4: Ability to describe and analyze the characteristics and applications of industrially important micro-organisms into modern industrial bioprocess perspective.

Bacteriology: General characteristics of Eubacteria, Archaebacteria and Cyanobacteria. Bacterial cell wall, Cell Membrane, Outer Envelopes (Slime layer, Capsule) Sub cellular structures-Ribosomes, Cytoplasmic Inclusion Bodies (Inorganic and Organic), Exospores, Endospore. Outer Membrane Projections-Flagella, Fimbriae, Pili, Bacterial chromosomes, Extra Chromosomal materials -Plasmids and Episomes (F, R, Ti, colicin as examples) 6hrs

Microbial growth: Nutritional requirements, culture media, factors affecting growth. Isolation and maintenance of pure cultures. Transport of sugars into bacterial cell – the bacterial phosphotransferase system. Modes of reproduction, growth curve, generation time, synchronous growth, Chemostat. Methods of control – physical and chemical agents. Action of antibiotics. 6 hrs

Virology: Classification and general properties of viruses. one step growth experiment, Lytic of T even Bacteriophage and lysogenic cycles of lambda phage, Choice between lysis and lysogeny of the lambda phage induction and SOS response of *E. coli* host, Phage typing and lysogenic conversion Assay of animal virus, plant virus and bacteriophage. 6 hrs

Food and Dairy Microbiology: Food spoilage, food preservation, fermented foods, exotoxins produced by bacteria. Contamination of milk by microorganisms. Bacterial count, reactions occurring in milk, Pasteurization and sterilization. Fermented milk products, cheese. 8 hrs

Environmental Microbiology: Interaction of microorganisms with environment. Bioremediation. Animal-microbe and plant-microbe interactions. Biological treatment of solid and liquid wastes and pollutants. Microorganisms and bioleaching. 7 hrs

Bioprocess Technology: Industrial micro-organisms and their characteristics. Manipulations *in vivo* and *in vitro* to produce high yielding strains. Industrial fermentation – principles of

fermentation, design of fermenters, batch and continuous operations, recovery of products. Production of ethanol, citric acid, penicillin, bioinsecticides, single cell protein and microbial enzymes. Immobilized enzymes. 12 hrs

References

1. Microbial Physiology, 2nd edition. IW Daves and IW Sutherland (1991) Blackwell Scientific.
2. Modern Food Microbiology by James MJ (1996) CBS Publishers.
3. A Modern Introduction to Food Microbiology by RJ Board (1983) Blackwell Scientific.
4. Biology of Microorganisms by Brock (1996) Prentice Hall.
5. Industrial Microbiology by Miller and Litsky (1976) McGraw Publishers.
6. Molecular Cell Biology by Baltimore et al., (1995) Scientific American Publication.
7. Microbiology by Prescott, Hartley and Klein (1993) WCB Publications
8. Milestones in Microbiology, Ed T. Brock (1991) ASM Press
9. Microbes in Action, A Laboratory Manual of Microbiology, Seley et al., WH Freeman
10. Microbiology, Pelczer, Reid and Kreig Tata McGraw Hill (1996).

CC 03: Metabolism I 45 hrs

Objectives

- *To study the metabolism and regulation of different biomolecules*
- *To know the interrelationships between different metabolites*
- *To calculate the energy yield from the metabolism of a biological compound*

Course Outcomes

CC01: To understand the main concept of metabolic biochemistry, their control and inter-relation.
CC02: To identify the importance of thermodynamic principles in coupling anabolic and catabolic processes in metabolism.
CC03: To explain the catabolism of carbohydrates, lipids and the role of enzymes involved in these pathways.
CC04: To relate the metabolic disorders and inborn errors.

Bioenergetics: Concepts of free energy, enthalpy and entropy, free energy change and standard free energy change of reactions, significance of free energy changes, effect of temperature on ΔG°, relations between K_{eq} and ΔG°. Group transfer reactions of ATP - phosphate group transfer potential of ATP and other high energy phosphate donors. 6 hrs

Biological oxidation: Mitochondrial electron transfer system – topology of electron carriers, sequence, specific inhibitors of ETC. Coupling of electron transfer to ATP synthesis – study of the effect of uncouplers, inhibitors and ionophores. Chemiosmotic hypothesis. Oxidative phosphorylation – Mechanism, structure and function of F_oF_1ATPase. Partial reactions of OP and P/O ratios. 12 hrs

Carbohydrate metabolism: Introduction, Glycolysis, fermentation reaction, glycogenesis, glycogenolysis, citric acid cycle, gluconeogenesis. Alternate pathways – HMP pathway, Enter-Doudoroff and glucuronate pathway and glyoxylate pathway. Regulation of blood glucose level. Disorders of carbohydrate metabolism: diabetes mellitus, GTT, glycogen storage disease, pentosuria and galactosemia. 13 hrs

Lipid metabolism: Introduction, hydrolysis of tri-acylglycerols, α-, β-, ω- oxidation of fatty acids. Oxidation of odd numbered fatty acids – fate of propionate, role of carnitine, degradation of complex lipids. Fatty acid biosynthesis, Acetyl CoA carboxylase, fatty acid synthase, ACP structure and function, Lipid biosynthesis, biosynthetic pathway for tri-acylglycerols, Synthesis of ketone bodies, phosphoglycerides, sphingomyelin and prostaglandins. Metabolism of cholesterol and its regulation. Energetics of fatty acid cycle. Disorders of lipid metabolism: hyperlipidemia, Gaucher's disease, Tay-Sach's and Niemann-Pick disease. 14 hrs

References

1. Lehninger Principles of Biochemistry 4th Ed by David L. Nelson and Michael M. Cox, WH Freeman and Company.
2. Principles of Biochemistry by Geoffrey Zubay. Publisher: McGraw Hill College.
3. Harper's Biochemistry (Lange Medical Books) Robert K. Murray, Daryl K. Granner, Peter A. Mayes and Victor W. Rodwell. Publisher: Appelton and Lange.
4. Bioenergetics by David G. Nicholls and Stuart J. Ferguson. Academic Press.
5. Bioenergetics at a Glance: An Illustrated Introduction (At a Glance) by D. Harris. Publisher: Wiley Blackwell
6. Fundamentals of Biochemistry: Life at the Molecular Level by Donald Voet, Judith G. Voet and Charlotte W. Pratt. Publisher: Wiley.

7. Biochemistry of Lipids, Lipoproteins and Membranes (4th Edn.) D.E. Vance and J.E.Vance. Pub: Elsevier Science B.V
8. Medical Biochemistry 4th Ed. by NV Bhagavan. Pub: Elsevier India Pvt. Ltd.
9. Biochemistry by Lubert Stryer. WH Freeman and Co.
10. Biochemistry; David Rawn, J. (1989) Neil Patterson Publishers

CC 04: Human Physiology 52 hrs

Objectives

- *To study the anatomy and functions of the major organs of the body*
- *To recognize the anatomical structures and explain the physiological functions of body systems.*

Course outcomes

CC01: To describe and understand the basic structure and anatomy of human organ systems.
CC02: To understand and explain physiological processes of organ systems.
CC03: Analyze the coordinated responses to maintain homeostasis in the context of variable and changing environment.
CC04: To demonstrate the ability to integrate physiology from cellular and molecular level to the organ system.

Tissues: Types and functions of epithelial tissue and connective tissues. Collagen, Elastin, Fibronectins, Laminin and other proteins of the extracellular matrix. Glycosaminoglycans and proteoglycans. Cell – cell interactions: tight junctions, gap junctions, desmosomes and hemi desmosomes. 5 hrs

Cytoskeleton: Elements of cytoskeleton - microtubules, microfilaments and intermediary filaments. Functions of cytoskeletal components in maintaining cells shape and in intracellular transport. Factors influencing polymerisation of cytoskeletal elements. Inhibitors of association and dissociation of cytoskeletal elements. Mechanism of treadmilling. Erythrocyte cytoskeleton. 8 hrs

Muscular system: Smooth, skeletal and cardiac muscles. Muscle proteins. Fine structure of muscle fibre, neuro-muscular junctions, fast and slow muscle. Phosphagens. Excitation of striated muscle, changes occurring in sarcolemma, transverse-tubular system and sarcoplasmic reticulum, mechanism of muscular contraction. Regulation of contraction. Calmodulin and its regulatory role. Muscular dystrophies. 7 hrs

Nervous system: Divisions of the nervous system, receptors, neurons and other cells of the nervous system. Resting and action potential, transmission of nerve impulses, synaptic

transmission, compounds affecting synaptic transmission, neuromuscular junction. Brain - chemical composition and metabolic adaptation, neurotransmitters and cAMP, biochemical aspects of learning and memory, enkephalins and endorphins. Autonomic nervous system. 6 hrs

Cardiovascular system: Systemic and pulmonary circulation. Structure of blood vessels. Regulation of cardiac activity. Blood volume and blood pressure. Composition and functions of plasma, Erythrocytes, Leucocytes, Thrombocytes, plasma proteins. Blood coagulation – mechanism and regulation, role of vitamin K, clot dissolution, anti-clotting factors. Lymph, Cerebro Spinal Fluid (CSF) – composition and analysis in diagnosis. 8 hrs

Digestive system**:** Structure of gastro-intestinal tract. Composition, functions and regulation of saliva, gastric, pancreatic, intestinal and bile secretions. Gastrointestinal hormones. Digestion and absorption of carbohydrates, lipids, proteins, nucleic acids and vitamins. Liver – structure and functions, Detoxification mechanisms. 6 hrs

Respiratory system**:** Air passages and lung structure, pulmonary volumes, alveolar surface tension, work of breathing and its regulation. Transport of respiratory gases. 5 hrs

Excretory system**:** Structure of nephron, glomerular filtration, tubular reabsorption of glucose, water and electrolytes. Tubular secretion. Homeostatic regulation of water and electrolytes, Acid-base balance. 5 hrs

Biochemistry of vision: Structure of rod and cone cells. Photosensitive pigments, Biochemical events occurring in photosensitive cells leading to initiation of nerve impulse. 2 hrs

References

1. Textbook of Medical Physiology 10th Ed by Arthur C. Guyton and John E. Hall, Harcourt Asia Pvt Ltd.
2. Essential Medical Physiology 3rd Ed by Leonard R. Johnson, Elsevier Academic Press.
3. Physiology 3rd Ed, by Linda Costanzo, Saunders Publishers.

4. Principles of Anatomy and Physiology 10th Edition by Gerard J. Tortora and Sandra Grabowski. Publisher: John Wiley and Sons.
5. Human Physiology: The Mechanisms of Body Function (Paperback) by Arthur J. Vander, James Sherman, Dorothy S. Luciano, Eric P. Widmaier, Hershel Raff and Hershal Strang. McGraw Hill Education.
6. Medical Physiology: Principles for Clinical Medicine 3rd Ed. by Rodney R. Rhoades and David R. Bell. Lippincott Williams & Wilkins.
7. Text Book of Biochemistry with Clinical correlations; Thomas Devlin [Ed.](1997), Wiley -Liss.
8. Cellular Physiology of Nerve and Muscle. Gary G Mathew (1998) Balckwell Scientific Inc.
9. Principles of Human Physiology; 4th Edn. Cindy L. Stanfield Pearson, (2010).
10. Principles of Biochemistry: Smith et al., [Ed.] (1986) McGraw Hill.

AC 01: Basic Biostatistics **26 hrs**

AC 02: Organic chemistry **26 hrs**

Objectives
The course aims to provide an advanced understanding of the core principles and topics of organic chemistry, and to enable students to acquire specialized knowledge and understanding of selected aspects needed in the pharmaceutical industry.

Course outcomes
CC01: To provide an insight of the core principles and topics of organic chemistry.
CC02: To understand the different types of reactions involving a biomolecule.
CC03: To empower the students' knowledge at atomic level with electron orientations which aids them in understanding the drug discovery programme.
CC04: advanced knowledge of different synthetic reagents and reactions of the drug discovery programme.
CC05: To acquire specialized knowledge and understanding of selected aspects needed in the pharmaceutical industry.

General concepts in Organic Chemistry:

Types of organic reactions Substitution, addition, elimination, isomerization, condensation (with one illustration each). Heterolytic and homolytic cleavage, electron delocalisation inductive,

resonance (comparison of acidity and basicity with examples) and hyperconjugation effects. Reactive intermediates, carbocations, carbanions and carbenes. 8 hrs

Benzene:

Structure of benzene - theory of resonance and molecular orbital concept, (bonding and antibonding molecular orbitals). Aromatic electrophilic substitution, General mechanism of aromatic electrophilic substitution – nitration, sulphonation. Orienting influence of –OH, - CH_3 and – NO_2 groups. 8 hrs

Phenols:

Phenols – structure and nomenclature, analogs of phenol, manufacture of phenol (from benzene), physical properties of phenol, acidic nature - comparison with alcohols, resonance stabilization of phenoxide ion, reactions of phenols (as an acid, reactions of –OH group, and reactions of the benzene ring - electrophilic substitution - acylation, carboxylation), Claisen rearrangement, Kolbe reaction, Reimer-Tiemann reaction. Test for phenol (ferric chloride test, phenolphthalein formation), antioxidant properties of phenols 10 hrs

References

1. Advanced Organic Chemistry: Reactions Mechanisms and Structure by Jerry March, Me. Graw Hill.
2. Molecular reactions and Photochemistry by Charles Dupey and O. Chapman, Prentice Hall.
3. Mechanisms and Theory in Organic Chemistry by T.H. Lowery and K.S. Rich Gardson.
4. The modern structural theory in Organic Chemistry by L.N.Ferguson, Pretice Hall
5. Physical Organic Chemistry by Jack Hine, Mc. Graw Hill

Lab 1 - General Biochemistry

1. Preparation of buffers and measurement of pH
2. Determination of saponification of lipid samples
3. Determination of iodine number of lipid samples
4. Determination of protein in given sample by Lowry method
5. Determination of protein in given sample by Biuret method

6. Estimation of total amino acids by Ninhydrin method
7. Estimation of tyrosine by Millon's method
8. Estimation of Total soluble sugars by anthrone method
9. Quantification of DNA, RNA and proteins
10. Determination of RNA by orcinol method
11. Determination of DNA by diphenylamine method
12. Estimation and comparison of Vitamin C in fruit juices

Lab 2 - Microbiology

1. Culture techniques – preparation of media, sterilization techniques
2. Isolation of pure culture – serial dilution, pour plate, spread plate, streak plate methods, and slab.
3. Staining techniques – simple, differential, negative, spore and fungal staining.
4. Determination of bacterial growth – growth curve.
5. Enzymatic reactions – Degradation of carbohydrates, proteins. Respiratory enzymes – catalase, oxidase. IMViC tests
6. Antibiotic assay, determination of minimum inhibitory concentration (MIC).
7. Assay of invertase from immobilized yeast cells.
8. Microbial production of lactic acid.

Lab 3 - Food Biochemistry practicals

1. Determination of ash content and moisture content.
2. Estimation of crude fiber content
3. Estimation of gluten from cereals
4. Separation and estimation of casein from milk
5. Estimation of β-carotene from carrot
6. Testing the effectiveness of blanching by peroxidase inactivity test
7. Estimation of calcium in food sample
8. Determination of lipid content in food samples.
9. Determination of peroxide values of lipids
10. Study of contents responsible for flavor of tea.

11. Study of presence of oxalate ions in fruit at different stages of ripening.
12. Qualitative testing of adulterants in food samples- milk, honey, turmeric powder, chilli powder.

Tutorial 1: Biochemical Calculations **40 hrs**

Qualitative and quantitative analysis: Introduction and types, gravimetric and volumetric. Indicators – types with examples. End point and standardization. 7 hrs

Acid-base chemistry: Concentrations based on volume and weight. Definition and numerical on molarity, molality, normality, equivalents, w/v %, w/w %, equilibrium constants (Keq). 6 hrs

Bronsted concept of conjugate acid –conjugate base pairs. Ionization of water. Concept of pH and pOH. Ionization – strong acid and base, weak acid and base. Relationship between Ka and Kb for weak acid and bases. 10 hrs

Buffers – Definition and working of a buffer system. Preparation of buffers using Henderson-Hasselbalch equation. Buffer capacity. Dilution of buffers. Amino acids as buffer system. 12 hrs

Spectrophotometery: Principle of spectrophotometry, preparation of protocol and standard graph with calculations. 5 hrs

II semester

CC – 05: Biochemical Techniques **45hrs**

Objectives: *The main objectives of this paper are to develop the key transferable skills required in scientific work. These include - Practical research skills; Analytical and presentation skills and Advanced scientific methods.*

Course outcomes

CO1: Ability to understand the fundamental thermodynamics and describe the operating principles behind various separation methods.
CO2: Ability to explain, evaluate principles of chromatography in industry.
CO3: Ability to outline principle and practical application of radio-isotope labelling processes in biological system.
CO4: Ability to discuss and demonstrate a working knowledge of spectro-photometric techniques and its application in industry.

Chromatography: Principle, procedure and applications of - Thin Layer Chromatography, Ion-exchange Chromatography, Molecular exclusion Chromatography, Gas-Liquid Chromatography, High Performance Liquid Chromatography, Fast Protein Liquid Chromatography and Affinity Chromatography. 10 hrs

Centrifugation: Principle and types. Ultracentrifugation - basic principles, Preparative and Analytical - Differential and density gradient centrifugation. Schlieren optical system - applications - determination of molecular mass and purity of macromolecules. 6 hrs

Electrophoresis: General principles. Support media. Electrophoresis of proteins - SDS-PAGE, 2D-PAGE, native gels, gradient gels, isoelectric focusing. Cellulose acetate electrophoresis. Detection, estimation and recovery of proteins in gels. Protein blotting. Electrophoresis of nucleic acids - agarose gel electrophoresis, DNA sequencing gels, pulsed field gel electrophoresis. 9 hrs

Radioisotopes: Nature of radioactivity - stable and radioactive isotopes, units, interaction of radioactivity with matter. Detection and measurement of radioactivity - GM counter, solid and liquid scintillation counter. Autoradiography. Applications of radioisotopes in the biological sciences. 6 hrs

Spectrophotometry: Principles and biochemical applications of UV-Vis spectrophotometry, fluorimetry, turbidometry and flame spectrophotometry. Principle and applications of CD, IR, NMR, ESR in the study of macromolecular structures. Mass Spectrometry– Electron Spray Ionization (ESI), Matrix Assisted Laser Desorption Ionization (MALDI). 14 hrs

References

1. Biophysics, 5th Edition, by R. Glaser, Springer, Netherlands
2. Principles and Techniques of Biochemistry and Molecular Biology 6th Ed. Keith Wilson & John Walker, Cambridge University Press
3. Encyclopedia of Spectroscopy and Spectrometry by George E. Tranter, John L. Holmes and John C. Lindon, Academic Press
4. Methods in Modern Biophysics, 2nd Edition, by Bengt Nolting, Springer Netherlands.

5. Biophysical Chemistry: Principles & Techniques Handbook by Avinash Upadhyay, Kakoli Upadhyay and Nirmalendu Nath, Himalaya Publishing House.
6. Chromatography: Concepts and Contrasts by James M. Miller, Wiley,
7. Modern Experimental Biochemistry 3rd Edition, by Rodney Boyer, Benjamin Cummings Press.
8. Biochemical Techniques: Theory and Practice, John F Roby. Publisher: SOS Free Stock.
9. Introduction to Electron Microscopy for Biologists: Methods in Cell Biology by Terry D. Allen. Academic Press.
10. Principle and Practice of Bioanalysis; Richard F. Venn (Ed.) Taylor and Francis (2000).

CC – 06: Nutritional and Clinical Biochemistry 45 hrs

***Objectives**: The course focuses on presenting the overall meaning and importance of nutritional biochemistry, particularly with reference to diet. The importance and deficiency consequence of each major and minor nutrient is presented.*

Course outcomes:
CC01: To understand the energy requirements of nutrients and their applications for normal health.
CC02: To study the importance of dietary component and their physiological functions.
CC03: To understand consequence of nutritional deficiency or excess in the clinical lab diagnosis of metabolic diseases
CC04: To analyse clinical management and the control of disorders by various function tests.

Basic concepts: Composition of human body, BMI, energy content of foods, measurement of energy expenditure; direct & indirect calorimetry, definition of BMR and SDA and factors affecting these; thermogenic effect of foods, energy requirements of man and woman and factors affecting energy requirements. Antinutrients. 4 hrs

Carbohydrates: Dietary requirements and sources of available and unavailable carbohydrates. Physico-chemical properties and physiological actions of unavailable carbohydrates (dietary fibers). Storage carbohydrates. 2 hrs

Proteins: Protein reserves of human body. Nitrogen balance studies and factors influencing nitrogen balance. Essential amino acids and concept of protein quality (importance of casein). Cereal proteins and their limiting amino acids. Protein requirement at different stages of development. 4 hrs

Protein Energy Malnutrition (PEM): Etiology, clinical features, metabolic disorders and management of Marasmus and Kwashiorkor. 2 hrs

Lipids: Major classes of dietary lipids, metabolism of plasma lipoproteins. Essential fatty acids and their physiological functions. 2 hrs

Electrolytes and pH balance: Electrolyte concentrations of body fluids, acid-base regulation in human body. Concept of metabolic and respiratory acidosis and alkalosis. 4 hrs

Minerals: Nutritional significance of dietary calcium, phosphorus, magnesium, iron, iodine, zinc and copper. 4 hrs

Vitamins: Dietary sources, biochemical functions and specific deficiency diseases associated with fat and water-soluble vitamins. Hypervitaminosis symptoms of fat-soluble vitamins. Nutritional requirements of vitamins for infants & children and during pregnancy and lactation. 4 hrs

Obesity: Definition and classification. Genetic and environmental factors leading to obesity. Obesity related diseases and management of obesity. Role of leptin in regulation of body mass. Eating disorders (Anorexia Nervosa, Bulimia Nervosa, Binge-Eating Disorder). 5 hrs

Disorders of liver, kidney and thyroid: Liver function tests, liver disease – hepatitis, cirrhosis and its diagnosis. Kidney function tests – clearance test, nephritic syndrome, glomerulonephritis, renal stones. Thyroid function tests – hypothyroidism, hyperthyroidism and goitre. 8 hrs

Diagnostic Enzymes: Diagnostic enzymes: principles of diagnostic enzymology, clinical significance of: aspartate aminotranferase, alanine aminotransferase, creatine kinase, aldolase, lactate dehydrogenase. 6 hrs

References

1. Handbook of Nutrition and Food 2nd Edn., by Carolyn Berdanier, Johanna Dwyer and Elaine Feldman, CRC Press

2. Nutritional Biochemistry and Metabolism: With Clinical Applications (Hardcover) By Maria C. Linder. Publisher: Appelton and Lange
3. Introduction to Human Nutrition, 2nd Edn. Michael J. Gibney, Susan A. Lanham-New, Aedin Cassidy, Hester H. Vorster, Wiley-Blackwell (2009).
4. Essentials of Food and Nutrition Vol I & II, By M. Swaminathan. Bangalore Printing and Publishing Co. Ltd.
5. Principles of Human Nutrition by Martin Eastwood. Publisher: Wiley Blackwell.
6. Textbook of Medical Biochemistry by MN Chatterjea and Rana Shinde, Jaypee Brothers.
7. Nutritional Biochemistry by S Ramakrishnan and S. Venkat Rao. TR Publications
8. Davidson's Principles and Practice of Medicine: A Textbook for Students and Doctors 15th Ed By LSP Davidson, J MacLeod and CRW Edwards. Publisher: Churchill Livingstone.
9. Medical Biochemistry by John W. Baynes and Marek Dominiczak. Publisher: Mosby. Clinical Biochemistry: An Illustrated Colour Text 3rd Ed by Allan Gaw, Michael Murphy, Robert Cowan, Denis O'Reilly, Michael Stewart and James Shepherd. Publisher: Churchill Livingstone.
10. Clinical Biochemistry by Richard Luxton. Scion Publishing Ltd.

CC – 07: Metabolism II 45 hrs

Objectives

- *To study the metabolism and regulation of different biomolecules*
- *To know the interrelationships between different metabolites*
- *Disorders related to aberrant metabolism*

Course outcomes

CC01: To study the metabolism and regulation of biomolecules and their related diseases.
CC02: To develop critical understanding of theories and principles in the field of amino acids, nucleic acids and heme metabolism.
CC03: To inter-relate knowledge acquired of metabolism with real-world situations by practicing healthy lifestyle
CC04: To interpret, analyze, and effectively communicate experimental data and conclusions of scientific protocol allotted.

Nitrogen Cycle: Introduction, biological and non-biological nitrogen fixation, *nif* genes, regulation, utilization of nitrate and nitrites, regulation of nitrate reductase. 5 hrs

Amino acid Metabolism: General metabolic reaction of amino acids– transamination, pseudotransamination, glucose – alanine cycle, oxidative deamination (glutamate dehydrogenase), minor pathways of amino acid degradation – transdeamination, amino acid oxidase, and non – oxidative deamination (α– deaminase, dehydrase, asparaginase and glutaminase). Assimilation of ammonia, formation of amino acid amides by glutamine synthetase and its regulation. 12 hrs

Urea cycle– regulation and metabolic disorders. Biosynthesis of creatine and creatine phosphate, polyamines– putrescine, spermidine and spermine, glutathione (γ–glutamyl cycle), physiologically active amines (serotonin, γ – amino butyric acid, histamine, and catecholamines – dopamine, epinephrine and epinephrine).

Special metabolism of methionine, histidine, phenylalanine, tyrosine, tryptophan, lysine, valine, leucine, isoleucine.

Disorders of amino acid metabolism: Albinism, alkaptonuria, cystinosis, cystinuria, Hartnup disease, histidinemia, homocystinuria, maple syrup urine disease, PKU, tyrosinemia. 12 hrs

Nucleotide Metabolism: Biosynthesis of purine and pyrimidine nucleotides and their inter conversion, regulation of biosynthesis. Other pathways of purine nucleotide formation. Biosynthesis of deoxyribonucleotides and coenzymes nucleotides. Chemical inhibition of the biosynthesis of nucleic acid precursors. Degradation of purine and pyrimidines.

Disorders of purine and pyrimidine metabolism: Gout, Lesch-Nyhan syndrome, oroticaciduria, xanthinuria 10 hrs

Heme metabolism: Biosynthesis and degradation of porphyrin, porphyrias. Hemoglobinopathies and Jaundice 6 hrs

References

1. Lehninger Principles of Biochemistry 4th Edn by David L. Nelson and Michael M. Cox, WH Freeman and Company.
2. Principles of Biochemistry by Geoffrey Zubay. Publisher: McGraw Hill College.
3. Bioenergetics by David G. Nicholls and Stuart J. Ferguson. Academic Press.

4. Bioenergetics at a Glance: An Illustrated Introduction (At a Glance) by D. Harris. Publisher: Wiley Blackwell
5. Fundamentals of Biochemistry: Life at the Molecular Level by Donald Voet, Judith G. Voet and Charlotte W. Pratt. Publisher: Wiley.
6. Biochemistry (Hardcover) 3rd Ed. by Donald J. Voet and Judith G. Voet. John Wiley and Sons.
7. Biochemistry of Lipids, Lipoproteins and Membranes (4th Ed.) D.E. Vance and J.E.Vance. Pub: Elsevier Science B.V
8. Biochemistry by Lubert Stryer. WH Freeman and Co.
9. Principles of Biochemistry by Robert Horton, Laurence A Moran, Gray Scrimgeour, Marc Perry and David Rawn. Pearson Education.
10. Harper's Biochemistry by RK Murray, DK Granner, PA Mayes and VW Rodwell. Appelton and Lange, Stanford.

CC – 08 Enzymology **52 hrs**

Objectives: *The main objective of this paper is to study the basics of enzymes, enzyme units, regulations and characteristics of various enzymes applicable in food industries and pharmaceuticals.*

Course outcomes
CC01: To classify and characterize the enzymes in each enzymatic class.
CC02: To analyze structure and functional relationships in biocatalyzed reactions.
CC03: To predict possible catalytic mechanisms of given reaction types.
CC04: To present strategies for the analysis of kinetic mechanisms of enzyme catalyzed reactions
CC05: To elucidate the enzyme inhibitory and regulatory mechanisms.
CC06: To account for clinical and industrial applications of biocatalysis.

Introduction: Nomenclature and classification of enzymes. Definitions with examples of holoenzyme, apoenzyme, coenzymes, prosthetic groups, cofactors, activators, inhibitors, active site, metalloenzymes, isozymes, monomeric enzymes, oligomeric enzymes and multienzyme complexes. Units of enzyme activity (definition of IU, Katal), specific activity of enzyme, enzyme turnover. Ribozymes and abzymes. 7 hrs

Kinetics of enzyme action: Concept of ES complex, active site, specificity, derivation of Michaelis-Menten equation for uni- substrate reactions. Different plots for the determination of K_m & V_{max} and their physiological significances. Importance of K_{cat}/K_m. Kinetics of zero & first

order reactions. Significance and evaluation of energy of activation. Collision & transition state theories. Classification of multi substrate reactions with examples of each class. Derivation of the rate of expression for Ping Pong, random and ordered Bi-Bi mechanisms. Use of initial velocity, inhibition and exchange studies to differentiate between multi substrate reaction mechanism. Reversible and irreversible inhibition. Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics, determination of K_i and numerical based on these. Suicide inhibitors. Sigmoidal kinetics – significance of sigmoidal behaviour, Allosteric enzymes and their regulation. Study of ATCase as typical allosteric enzyme. 18 hrs

Mechanism of Enzyme Action: Acid-base catalysis, covalent catalysis, proximity, orientation effect. Strain and distortion theory. Chemical modification of active site groups. Site directed mutagenesis of enzymes. Mechanism of action of chymotrypsin, lysozyme, triose phosphate isomerase and alcohol dehydrogenase. 8 hrs

Enzyme Regulation: General mechanisms of enzyme regulation, product inhibition. Reversible (glutamine synthase & phosphorylase) and irreversible (proteases) covalent modifications of enzymes. Mono cyclic and multicyclic cascade systems with specific examples. Feed back inhibition and feed forward stimulation. Allosteric enzymes, qualitative description of 'concerted' & 'sequential' models for allosteric enzymes. Half site reactivity, Flipflop mechanism, positive and negative co-operativity with special reference to aspartate transcarbamoylase & phosphofructokinase. Protein-ligand binding measurement, analysis of binding isotherms, Hill and Scatchard plots. 10 hrs

Multienzyme system: Occurrence, isolation & their properties: Mechanism of action and regulation of pyruvate dehydrogenase & fatty acid synthase complexes. Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase. 5 hrs

Coenzymes: Structure and biological functions of NAD, NADP, FAD, FMN, TPP, THF, biotin, Coenzyme Q, ascorbic acid, lipoic acid and PLP. 4 hrs

References

1. Fundamentals of Enzymology: Cell and Molecular Biology of Catalytic Proteins (Paperback) by Nicholas C. Price and Lewis Stevens. Oxford University Press.
2. Advances in Enzymology: by Alton Meister. John Wiley and Sons Inc.
3. Lehninger Principles of Biochemistry 4th Ed by David L. Nelson and Michael M. Cox, WH Freeman and Company.
4. Principles of Biochemistry by Geoffrey Zubay. Publisher: McGraw Hill
5. Biochemistry: Biomolecules, Mechanisms of Enzyme Action and Metabolism Vol 1 (Hardcover) by D Voet. John Wiley and Sons.
6. Enzymatic Reaction Mechanisms by Perry A. Frey and Adrian D. Hegeman. Oxford University Press.
7. Comprehensive Enzyme Kinetics by Vladimir Leskovac. Publisher: Kluwer Academic / Plenum Publishers.
8. Enzyme Kinetics: A Modern Approach by Alejandro G. Marangoni. Publisher: Wiley Blackwell.
9. Enzyme Kinetics and Mechanisms by Kenneth B. Taylor. Kluwer Academic Publishers.
10. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry by Trevor Palmer.

AC 03: Research Methodology **26 hrs**

Objectives

To enable the students to

- *Understand the methodology of research/ principles and techniques.*
- *Develop skill in conducting research from planning to report writing.*

Course outcomes: *Enable students to identify the overall process of designing a research study from its inception to its report. Students can select and define appropriate research problem, organize and conduct research in a structured manner. Also enables students to prepare a project proposal, to write a research report, articles and thesis in a decipherable manner.*

Unit I Introduction to Research

Meaning, definition, objectives and characteristics of research. Types of research- basic research (fundamental research), applied research, action research, descriptive research, analytical research, evaluation research, historical research, exploratory research, industrial research, development research. **4 hrs**

Unit II Research Process

Research design, important experimental designs, sample design. Census and sample method; theoretical basis for sampling, methods of sampling, size of sample, merits and limitations of sampling, sampling and non-sampling errors, reliability of sampling.

Data and methods of data collection; types of data- primary and secondary data. Primary data collection methods- direct personal investigation, direct oral investigation schedules and questionnaires, interviews and type of interviews. Pre-testing and pilot study. **6 hrs**

Unit III Measurement and scaling technique

Measurement in research; measurement scales- nominal scale, ordinal scale, interval scale, and ratio scale. Sources of error in measurement.

Scaling- meaning, classification basis, important scaling techniques- rating scale, ranking scale, arbitrary scale, summated scale. **4 hrs**

Unit IV Intellectual Property Rights

Patenting - definition of patent. Patenting and fundamental research. Product and process patents, Patent infringement, Copyright infringement and Trademarks. **2 hr**s

UNIT-V: Scientific writing

Research resources: reviews, abstracts, books, journal and magazine articles- Exploration and communication; Resources: online and print; Review of latest literature (peer reviewed). Logical format for writing thesis and papers. Essential features of abstract, introduction, review of literature, materials and methods, and discussion. Reference styles. Understanding Plagiarism: definition, unintentional plagiarism and consequences; Collaborative work. **6 hrs**

Unit IV: Data analysis using Excel:

Analysis of quantitative data and effective presentation with tables, graphs etc., Use of Excel for Formulae Function, Charts and Graphs, Table formula, t-test, Anova and Correlation. **4 hrs**

References

1. Research Methods for the Biosciences. Holmes, Moody & Dine. Oxford University Press.

2. Experimental Design for Biologists. David J. Glass. Cold Spring Harbor Laboratory.
3. Experimental Design for the Life Sciences. Ruxton & Colegrave. Oxford University Press.
4. Research Methodology, Kothari, C. R. (2005) New Delhi, Vikas Publication House.
5. Sucessful Scientific writing: A step-by- step Guide for Biomedical Scientists. 2nd ed. Matthews. Cambridge University Press, 2001.
6. Green. R. H. Sampling Design and Statistical Methods for Environmental Biologists. John Wiley & Sons, 1979.
7. Swain AKPC (2008), A Textbook Of Research Methodology, 1st Edition, Ludhiana, Kalyani Publishers
8. Sunder rao and Richardb (2006), an introduction to bio statistics, a manual for students in health sciences, 4th edition, New Delhi, Prentice Hall
9. Gupta S.P.,Statistical methods, 28th ed. Sultan chand and Co, New Delhi,1998.
10. Sinha, S.Cand Dhiman,A.K.(2002) Research methodology, Ess Ess Publication 2 Volumes.

AC 04: Biochemical Toxicology 26 hrs

Objectives

- *To study the noxious effects of chemical substances on living systems.*
- *To understand the metabolism and fate of drugs*

Course Outcomes

CC01: To introduce the various facets and the common terminologies used in the study of toxicology.
CC02: To interpret the principles and factors affecting disposition of toxicants.
CC03: To understand the mechanisms of carcinogenesis and mutagenesis and to demonstrate bioassay procedures involved in detecting toxicity.
CC04: To classify the various types of toxicants, their origins and health implications of toxic exposures.

General principles of Toxicology: Definition, Different facets of toxicology and their interrelationships, dose descriptors (DNEL, NOAEL, LOAEL, ED_{50} and LD_{50}), dose-response curves. Factors affecting toxicity – environmental, routes, duration and frequency, and form of exposure. Interactive effects of toxicants. Types of toxicity - acute, subchronic, chronic exposure, determination of ED_{50} and LD_{50} values. 4hrs

Disposition of Toxicants:PKPD. Factors affecting disposition of toxicants - absorption, distribution, biotransformation, elimination (ADME). Absorption through gastro-intestinal tract, lungs, skin. Distribution – apparent volume of distribution, storage in tissues, blood-brain barrier, passage across placenta, redistribution. Biotransformation - Phase I and II reactions. Excretion - urinary, fecal, exhalation, other routes. Antidotal therapy. 6hrs

Genetic toxicology: Chemical mutagenesis. Nature, mechanism and biological features of chemical carcinogenesis, carcinogens. Teratogenesis, teratogens and their action. Tests for mutagenicity, carcinogenicity, genotoxicity, Ames test. 4 hrs

Target organ toxicity: Skin- skin as a barrier, dermatitis, acne, urticaria. Toxic responses of the blood - blood as a target organ, toxicology of erythron, leukon and platelets. Toxic responses of the liver - physiology and pathophysiology, factors in liver injury, mechanism of liver injury. Toxic responses of the respiratory system - lungs structure and functions, pulmonotoxic agents, pathogenesis of chemical induced damage, acute and chronic responses of lungs to injury. 6 hrs

Food toxicology: Toxicology of food additives, animal and plant toxins. 2 hrs

Metal toxicity: Heavy metals - arsenic, mercury, lead and cadmium. Environmental factors affecting metal toxicity. 4 hrs

References

1. Industrial Toxicology by Williams P L &Burson J L (1985) Van- Nostrand Reinhold, New York.
2. Principles and methods of toxicology by Hayes A W (1988), II edition, Raven press New York.
3. Toxicology by Stewart C P&Stolman A (1960), vol I, Academic press, New York.
4. General and applied toxicology by Marrs and Turner (1995), Macmillan Press Ltd.
5. Basic environmental toxicology by Lorris G. Corkerhem and Barbara SS (1994), CRP Press Inc.
6. Molecular biotechnology by Barnard R Glick & JJ Pasternak (1994) 2nd Ed, ASM Press

Lab 1 - Biochemical techniques

1. pH metric titrations of weak acid vs. strong base.
2. pH metric titration of amino acid (neutral) vs. strong base and acid.
3. Descending /Ascending/Circular paper chromatography
4. Thin layer chromatography – amino acids.
5. Native PAGE for activity staining of enzymes.
6. Separation of proteins by SDS-PAGE electrophoresis.
7. Agarose gel electrophoresis of DNA.
8. Differential solubility of albumin and globulin (A/G ratio).
9. Determination of Na^+ and K^+ using flame photometer.
10. Determination of molar extinction coefficient of riboflavin
11. Isolation and estimation of glycogen form liver.
12. Determination of pI of casein from milk.

Lab 2 - Clinical Biochemistry

1. Estimation of glucose in blood by Asatoor and King's method.
2. Estimation of blood urea by Diacetyl monoxime method.
3. Estimation of haemoglobin in blood by Wong's method.
4. Estimation of serum cholesterol by Zack's method.
5. Estimation of serum creatine and creatinine by Zaffe's method.
6. Estimation of bilirubin in blood.
7. Qualitative analysis of urine.
8. Estimation of uric acid in urine by Caraway's method.
9. Estimation of inorganic phosphate in urine by Fiske-Subbarow method.
10. Estimation of 17-ketosteroid in urine by Zimmerman's method.
11. Estimation of chloride in urine by Volhard-Arnold method.

Lab 3: Enzymology

1. Assay of LDH
2. Assay of SGOT/SGPT

3. Determination of total activity of salivary α-amylase
4. Determination of Km and Vmax of α-amylase
5. Determination of total activity of pea esterase.
6. Determination of Km and Vmax of pea esterase.
7. Determination of optimum pH and temperature of pea esterase.
8. Determination of type of inhibition (reversible or irreversible) of pea esterase.
9. Determination of specific activity of alkaline phosphatase.
10. Determination of I_{50} of alkaline phosphatase.
11. Determination of specific activity of Urease

Tutorial 02: Hormone Chemistry **40 hrs**

Classification and Mechanism: Endocrine organs and their location. Hormones - definition, classification based on receptors, hormone cascade system involving CNS, hypothalamus, anterior pituitary, target gland, feedback mechanisms, classification of hormones (polypeptides, glycoproteins and POMC peptides), major polypeptide hormones and their actions, genes and formation of polypeptide hormones - POMC peptides and vasopressin. 20hrs

Hormone Receptors and Regulation: Steroid hormone receptors, intracellular protein receptors, structural organization of receptor protein, hormone binding domain, antigenic domain and DNA binding domain, organizations of functional elements - hormone response elements, positive and negative transcriptional effects of S.R, receptor activation - upregulation and down regulation, apoptosis - steroid hormone action at cell level, multiple endocrine neoplasia - different types. 20hrs

References

1. Textbook of biochemistry (with clinical correlation) by Devlin, Wiley-Liss; 6 Edition (2005)
2. Textbook of endocrinology by Wilson and Foster, W.B. Saunders Co.
3. Harper's Biochemistry by R.K. Murray et al. McGraw-Hill Medical; 27 Edition (2006)

III Semester

EC 01: Immunology **45 hrs**

Objectives

- *About the structural features of the components of the immune system as well as their functions*
- *The primary emphasis of this course will be on the mechanisms involved in immune system development and responsiveness.*
- *The major experiments that allowed the elucidation of these mechanistic features will be featured to help understand how immunologists think and work.*

Course Outcomes

CC01: To afford an exploration of lymphocytes, antigen presentation, humoral and cellular immune responses, inflammation, complement and cytokines.
CC02: To introduce the concept of clonal selection, gene organization and class switching.
CC03: To promote an understanding of hypersensitivity, autoimmunity, immunodeficiency diseases, tumor and transplantation immunology.
CC04: To describe and employ antigen-antibody interactions in different immunological and serological tests in the laboratory.

Infection: Types of infection and nature of infective agents. Nonspecific host defense mechanisms. Anatomical barriers; lysozyme and other antimicrobial agents. Phagocytosis and phagocytic cells, neutrophils, monocytes and macrophages. Inflammation. Toll-like receptors and pattern recognition. 6 hrs

Immunoglobulins: Structure and functions of immunoglobulins, Types; isotypes and idiotypes, isoantibodies. Methods of raising antibodies. Monoclonal antibodies – production, purification and application. Application of Polyclonal antibodies. 5 hrs

Complement system: Introduction, alternate and classical pathway, regulation. 4 hrs

Immunity: States of immunity, innate and acquired immunity, naturally and artificially acquired passive and active immunity. Immunization practices, use of toxoids, killed and attenuated organisms. Surface components and newer vaccines, production of vaccines. Primary and secondary response. 6 hrs

The Immune System: Recognition of self and non-self, the major histocompatibility antigens, H-2 and HLA antigens, Antigenicity; humoral and cell mediated immunity. T and B lymphocytes; origin, differentiation, characteristics and functions, nature of surface receptors, antigen processing and presentation. T and B cell interaction. Cytokines, monokines, lymphokines and their functions. 7 hrs

Molecular Immunology: Theories of antibody formation; clonal selection and network, Genetics of antibody diversity, germ line and somatic mutation theories; immunoglobulin, MHC and TCR gene organization, and their recombination, class switch of Ig genes. 5 hrs

Clinical Immunology**:** Immune disorders; hyper sensitivity, autoimmune and immunodeficiency diseases. SCID mice as a model system. Tissue transplantation; auto -, iso-, allo-, and xenografts, tissue matching, transplantation rejection, mechanism and control, tumor immunology. 6 hrs

Immunoassay methods: Antigen-antigen interaction – affinity and avidity, determination of affinity and avidity constants. Principle, procedure and applications of Immunoprecipitation. Neutralization, agglutination, compliment fixation, immunodiffusion, immunofluorescence, RIA, ELISA, micro ELISA Techniques. 6 hrs

References

1. Antibodies- A Laboratory Manual; E. D. Harlow, David Lane, 2nd Edn. CSHL Press (2014).
2. Basic and Clinical Immunology; Stites et al., [Ed] (1982) Lange.
3. Roitt's Essential Immunology; Ivan, M. Roitt & Petrer J Delves (2001) Blackwell Science.
4. Immunology; Roitt et al., Mosby (2001).
5. Kuby Immunology; Oven, Punt, Stranford, 7th Edn. W.H. Freeman (2013)
6. Immunology at a Glance: J.H.L. Playfare [edn.] Blackwell Science, (1987).
7. Introduction to Immunology; Kim Bell [Ed.,] 3rd Edn. McMillan (1990).
8. Immunology; Jan Klein [Ed.], Blackwell Science (1990).
9. Understanding Immunology (Cell and Molecular Biology in Action); Peterwood, Pearson Education Ltd. (2006).
10. Immune System; M. C. Connel et al., Eds. (1981) Blackwell Science.

EC 02: Plant Biochemistry 45 hrs

Objectives

- *Understand the characteristics of a few natural products, their synthesis and mechanism.*
- *Describe a few significant biochemical processes in plants*
- *Use standard laboratory procedures to estimate various significant biochemical products occurring in plants*

Course outcomes

CC01: To understand the characteristics of few natural products, their synthesis and mechanism.
CC02: To describe various significant biochemical processes in plants.
CC03: To learn the structure, function and biosynthetic pathways of essential biochemical molecules including their key chemical and physical properties.
CC04: To demonstrate plant cell structure and organization and apply specific biochemical functions to all components of plant cell structure.

Seed and seed germination: Characteristics and composition of seeds. Germination- factors affecting and influencing, biochemical changes. Phytochrome- definition and their role- light dependant germination. 4 hrs

Plant nutrients: Definition, classification, general role of calcium, magnesium and iron. Functions and deficiency symptoms of macro and trace elements. Transport of water and nutrients. 4 hrs

Plant Hormones: Introduction, phytohormones, discovery, nomenclature. Structure, functions and biosynthesis of: Auxins (tryptamine pathway) and ethylene from methionine. Structures and functions of gibberellins, cytokinins, abscisic acid. Brassinosteroids and bastasins. 4 hrs

Photosynthesis: Photosynthesis: – Light and dark reactions, Emerson effect. Photo systems – mechanism of pigment excitation, types of pigments. Photophosphorylation – Calvin-Benson Cycle, Hatch and Slack pathway. Photorespiration. 5 hrs

Natural Products:

Alkaloids: Introduction, general characteristics, general method of extraction. Classification with examples. Structure, sources and medicinal uses of nicotine. Medicinal uses of common plant alkaloids. 5 hrs

Phytochemicals**:** Definition and uses. Flavonoids-biosynthesis from phenyl propanoid pathway. Molecular structure of flavone backbone. Important flavonoids and their biological significance.

List of the flavonoids present in citrus fruits, tea leaves, wine and dark chocolate. Biological roles of curcumin. Polyphenols- Occurrence and biological importance. 5 hrs

Terpenes: Introduction and classification with examples. Biological importance, structure and occurrence of the following: limonene, menthol, phytol, lycopene, Structure and importance of beta carotene and plastoquinone. 4hrs

Defence system in plants: Roles of phytoanticipins, NADPH oxidase, defense proteins, NO, phenolic compounds, jasmonic acid, ethylene and phytoalexins. Reactive oxygen species and their generation, enzymic and non-enzymic components of antioxidative defence mechanism. Genetic basis of pathogen resistance and effects of phytotoxins on plants. Biochemistry of herbicide action. 4 hrs

Stress physiology: Responses of plants to biotic (pathogen and insect) and abiotic (water, temperature and salt) stresses; mechanism of resistance to abiotic stress and tolerance to abiotic stress. 4 hrs

Gene transfer and expression in plants : *Agrobacterium* mediated transformation, Ti plasmid, mechanism of T-DNA transfer, Ti-plasmid derivatives as plant vectors (disarmed T-DNA), Cointegrate and binary vectors, selectable markers for plants, control of transgene expression in plants. Plant expression vectors; CaMV and TMV vectors. Transgenic plants- Bt cotton, golden rice. 6 hrs

References

1. Biochemistry and molecular biology of plants, Bob B. Buchanan, Wilhelm Gruissem and Russel L. Jones, IK International Pvt. Ltd.
2. Plant Physiology, 4th Ed., By Lincoln Taiz and Eduardo Zeiger, Sinauer Associates Inc.
3. Introduction to Plant Physiology, William G. Hopkins, Wiley Interscience.
4. Advances in Plant Physiology Series (Volumes 1-25), Pub: Springer Science
5. Plant Toxicology, Bertold Hock and Erich Elstner, Marcel Dekker.
6. Plant Hormone Signaling, Peter Hedden and Stephen Thomas, Blackwell Publishing.
7. Integrative Plant Biochemistry: 40 (Recent Advances in Phytochemistry) By John Romeo. Elsevier Science.

8. Plant Biochemistry, PM Dey and JB Harborne. Academic Press Inc., US.
9. Plant Physiology, Biochemistry and Molecular Biology, David T. Dennis and David H. Turpin. Publisher: Longman
10. Plant Biochemistry and Molecular Biology, Hans-Walter Heldt. Oxford University Press.
11. Physiology and Molecular Biology of Stress Tolerance in Plants (Hardcover) By K.V. Rao Madhava, A.S. Raghavendra and K. Janardhan Reddy. Kluwer Academic Publishers.
12. Plant Biochemistry, Caroline Bowsher, Martin Steer and Alyson Tobin. Garland Publishing Inc., US.
13. Plant Physiology and Biochemistry, H.S. Srivastava and N. Shankar. Rastogi Publications.
14. Textbook of Plant Physiology, Biochemistry and Biotechnology By S. Verma and Mohit Verma. S. Chand and Co.
15. Plant Biochemistry, Hans-Walter Heldt. Academic Press.

EC 03: Cell and Membrane Biology 45 hrs

Objectives

- *Demonstrate an understanding of the structure, physico-chemical properties and function of biological membranes, different techniques used in membrane study and processes involved in the insertion of integral membrane proteins into the lipid bilayer.*
- *Demonstrate an understanding of protein sorting, targeting and degradation.*
- *Demonstrate an understanding of cell cycle and its control through apoptosis.*

Course Outcomes

CC01: To promote an understanding of membrane structure, physico-chemical properties and function and the various techniques used in membrane study.
CC02: To introduce the mechanism of membrane transport, protein sorting, targeting and degradation.
CC03: To describe and compare the process and organization of signal transduction pathways.
CC04: To summarize the general mechanism of cell division and their regulation through different check points of cell cycle and its control through apoptosis.

Membrane lipids and proteins: Structure and composition of lipid and glycolipid components of plasma- and organelle membranes. Self-assembly and hydrophobic interactions. *Polymorphism of membrane lipids:* micelles, monolayers, bilayers and hexagonal phases. Liposomes as model membrane systems. Phase behaviour of bilayer structures: the gel to-liquid crystalline phase transition. Membrane fluidity and its regulation. Singer-Nicholson fluid mosaic model.

General features of membrane protein structure. 3-D structures of typical integral membrane proteins: glycophorin, bacteriorhodopsin, photosynthetic reaction centre. Lipid-anchored

membrane proteins. Lateral and rotational diffusion of integral membrane proteins. Fluorescence photo bleaching recovery (FRAP). Lipid-protein interactions. Freeze-fracture electron microscopy. Atomic force microscopy. 10 hrs

Membrane transport: Transport processes; Permeability properties of lipid bilayers. Diffusion and carrier-mediated transport; *Ionophores;* Channel formers and mobile carriers. *Protein mediated membrane transport*; *Passive transport;* glucose transporter, Band 3. *Active transport;* uniport, cotransport- symport, antiport, electrically neutral, electrogenic transport, Na^+K^+-ATPase. Transport across organelle membranes, *Ion-transporting ATPases;* P-, V-, F-ATPases, structure, mechanism of action and regulation. ABC-transporters, MDR1. Diseases of membrane: P-glycoprotein-MDR1 and CFTR. 8 hrs

Protein sorting, targeting and degradation: Post translational modifications of proteins, role in targeting. Signal peptide (ERLS), role of SRP in translation of secreted proteins. NLS, Mitochondrial & Chloroplast LS. Chaperones, HSPs in protein folding. Lysosomal pathways (endocytosis, crinophagy, macroautophagy, microautophagy, direct translocation from cytosol). Ubiquitin-proteasome pathway, N-end rule. 10 hrs

Signal Transduction: History & Discovery. Introduction and organization of signal transduction, amplification. Signal transduction pathways; 1) G-protein linked [epinephrine], 2) Ion –channel [Ach], 3) Tyrosine kinase (RTC) [insulin], and 4) Intrinsic enzyme/cytokine [GF] receptors. *Effectors of inter-cellular signaling* Adenylate cyclase, Phospholipase-C, Nitroxide synthase, guanylate cyclase and their activation. *Second messengers;* [cAMP, CREB, cGMP, phosphoinositides, arachidonic acid, Ca^{2+}, and NO]. Cascades downstream of RTK; Erk-fos-jun-cyclin-D, MAPK-Ras-Raf-Sos. Nuclear signaling: Steroid hormone as an example. Transcriptional activation by phosphorylation cascade; CREB. 12 hrs

Cell Cycle: Growth factors and cytokines, phases and check points of cell cycle, cell cycle arrest at G1 and their regulation. Restriction of DNA replication, changes in chromosomal organization. Cyclins and cyclin-dependent kinases. Entry of cell to M-phase from G2, role of MPF. Regulation of cdks by inhibitors of cdks. Promotion of G1/S by growth factors. Tumor suppressors; activation by P53, Vit-D, TGF- ß. 5 hrs

References

1. Biochemistry; Voet, D. and Voet, J.G. [Eds.] (1999) 3rd Ed. Jhon Wiley and sons.
2. Human Physiology; Vander Sherman & Luciano (2001), McGraw-Hill.
3. Human Physiology; Stuart Era Fox, (2001) McGraw-Hill.
4. Biochemistry; David Rawn, J. (1989) Neil Patterson Publishers.
5. Biochemistry with Clinical correlations; Thomas Devlin [Ed.] (2002), Wiley-Liss.
6. Molecular Biology of the Cell; Albertis, et al., (2002), Garland Science.
7. Principles of Biochemistry; Lehninger et al., [Eds.] (1997) 2nd Edn. Worth Publishers.
8. Principles of Biochemistry; Smith et al., [Ed.] (1986) McGarw Hill.
9. The Biochemistry of Cell Signalling; Ernst Helmreich, OUP, (2001)
10. Basic Neurochemistry; George Siegel et al., (1999) Wippincott, Williams and Wilkins.
11. Molecular Cell biology; Lodish et al., W.H. Freeman & Co. (1999).
12. Molecular Cell Biology, Baltimore et al. (1995) Scientific American Publication.

EC04: Molecular Biology - I 52 hrs

Objectives

- *Understand the Central Dogma of molecular biology*
- *Provides insight on Replication process in prokaryotes and eukaryotes*
- *To describe the processes of transcription in both prokaryotes and eukaryotes at the molecular level*
- *Provide insight on DNA repair mechanisms*

Course outcomes

CC01: To provide an insight on the tools of replication process and to differentiate between prokaryotes and eukaryotes.
CC02: To understand genotoxic, cytotoxic and mutagenic damages caused due to chemical alterations on DNA and to focus on their repair mechanisms.
CC03: To impart knowledge on the viral replication that will aid in the development of newer tools to improve the health of humans and animals.
CC04: To provide detailed knowledge about the functioning of a cell at the molecular level with respect to promoters, transcriptional factors and transcript processing.
CC05: To understand the qualities of the genetic code in determining the amino acid sequence of a polypeptide.

DNA Replication: Central dogma of molecular biology. Unidirectional and bidirectional replication, semi-conservative and semi-discontinuous replication. Replication of double stranded DNA, initiation and regulation. Okazaki fragments. Isolation of ARS of yeast, ORC, Licensing factors and regulation of eukaryotic DNA replication. Inhibitors of DNA replication.

DNA polymerase I, II, III, IV and V, helicase, DNA ligase, DNA topoisomerase. Processivity and fidelity of replication. Nearest neighbour base frequency analysis. 13 hrs

DNA repair: Damaging agents and damage recognition. Direct repair, Miss-match repair assay for mismatch repair, Base excision repair (BER), Nucleotide excision repair (NER), SOS and Rec-A. Eukaryotic BER and NER. 5 hrs

Extra chromosomal replication: Replication of phage DNA ØX174, T7, SV-40, rolling circle model of replication. Replication of RNA viruses - Picorna (Polio), rhabdo virus (VSV), orthomixovirus (influenza virus). Structure and mechanism of RDR pol. Retroviruses, Replication of Q virus. 8 hrs

Transcription: Co-linearity of genes and proteins. RNA biosynthesis in prokaryotes and eukaryotes: initiation, elongation and termination. Roles of the RNA polymerase I, II and III. Sensitivity to K-amanitin. Structure and function of sigma factor, sigma cycle. TATA Box, Class-I and Class-III promoters, enhancers and silencers. Class-II pre-initiation complex, foot-printing DAB. FRET assay. Role of K-subunit and L-subunit. Rho- dependent and independent termination. Structure and function of TFIID, TBP and associated factors. Processing of eukaryotic RNA, cap addition, poly A tail addition, RNA editing. Processing of tRNA and mRNA transcripts. 19 hrs

Genetic code: Experimental results leading to deciphering genetic code, coding properties of mRNA, tRNA. Use of synthetic oligonucleotides, base pairing between codon and ani-codon, Wobble base pairing. Properties of genetic code, deviation from universal genetic code. 7 hrs

References

1. Basic Virology; Wagner and Hewlett; Blackwell Science, (2004)
2. Lewins Gene XI; J.E. Krebs, E.S. Goldstein, and S.T. Kilpatrick, Jones and Barttlett Publishers (2012).
3. Molecular Biology of the Cell, Alberts et al., Garland Publications, (2012).
4. Molecular Biology, David Freifelder, Narosa Publishers, (1997).

5. Molecular Biology Robert F. Weaver, McGraw Hill (2012).
6. Microbial Genetics; Maloy et al., Jones and Bartlett Publishers, (1994).
7. Molecular biology and Biotechnology; 4th Edn., J.M. Walker and R. Rapley, RSC (2000).
8. Molecular Biology of Gene; Watson, J.D. et al., 5th Edn. Pearson Education; (2004).
9. Principles of Virology; S.J. Flint et al., ASM Press (2000).
10. Biochemistry and Molecular Biology; 5th Edn. D.Papachristodoulou, A. Snape, W.H. Elliott, and D. C. Elliott Oxford University Press (2014)
11. Chromatin structure and Gene Expression; 2nd Edn. Sarah Elgin, Jerry Workman, Oxford University Press (2000)
12. Molecular Cell Biology; Harvey Lodish 5th Edn. (2010)
13. Biochemistry 5th Edn. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer (2011).
14. Genome Stability: DNA Repair and Recombination; James Haber, Garland Science (2013)
15. Retroviruses; Coffin JM, Hughes SH, Varmus HE, editors; CSH Press, (1997)
16. Viruses: Biology, Applications, and Control; David Harper, Garland Science (2011).

AC 05: Basic Bioinformatics **26 hrs**

Unit	Contents	No: of Hours
I - Biological Databases	NCBI, SWISSPROT, PDB, SCOP, KEGG	**3 hrs**
II - Computational sequence analysis	Pair wise Alignment, Multiple Alignment, Gap, Gap penalty, Global Alignment, Local Alignment, BLAST.	**3 hrs**
III - Proteomics tools in SWISSPROT	CFSSP, Compute pI/MW, FindMod, Biochemical Pathways.	**3 hrs**

IV - Protein Structure Prediction	Significance of Molecular Structure Prediction, Tertiary structure prediction by homology modelling and tools. Structure validation using RAMPAGE	**5 hrs**
V – Chemical Drawing, Ligand Database, Binding Pocket finder, Molecular Docking and Visualisation	With Reference to Hexokinase-Glucose-2Deoxyglucose interaction studies – ACD ChemSketch, ZINC, CASTp, AutoDock, Discovery Studio.	**12 hrs**

References

1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins
By: Andreas D. Baxevanis (Ed), B. F. Francis Ouellette (Ed)
Edition: 3nd edition, October 2004 Publisher: Addison-Wesley
2.Bioinformatics: Genes, Proteins and Computers
By: C. A. Orengo, D. T. Jones, J. M. Thornton (Ed), D. T. Jones (Ed)
Edition: 1st edition, May 2003 Publisher: Roultledge
3. Introduction to Bioinformatics
By: Arthur M. Lesk
Edition: 1st edition, September 2002
Publisher: Oxford University Press

Lab 1-Immunology

1. Isolation of lymphocytes from peripheral blood by Ficoll Method
2. Extraction of antibody (IgY) and estimation of protein content in the isolated IgY sample
3. SDS-PAGE of antibodies
4. Radial immunodiffusion
5. Ouchterlony double diffusion
6. Rocket electrophoresis
7. Enzyme linked Immunosorbent Assay

8. Blood typing
9. Labeling antibodies with biotin
10. Western Blotting of proteins and immunodetection
11. Hemagglutination

Lab 2 - Fractionation Techniques

1. Approaches to biochemical investigations: Whole animal studies perfusion of isolated organs, tissue and cell culture techniques. Cell fractionation techniques.
2. Studies on microbial cell lysis by sonication.
3. Separation of cell organelles by differential centrifugation technique.
4. De-pigmentation of extract, solvent extraction and estimation of total phenols.
5. Isolation, estimation and identification of antinutritents – phytic acid / tannins.
6. Isolation, estimation and identification of antioxidants from plant source.
7. TLC of alkaloids
8. Separation of plant pigments (chlorophylls) by adsorption column chromatography.
9. Isolation of phospholipids from egg.
10. Separation of lipids by thin layer chromatography.

Lab 3 - Protein Chemistry

1. Extraction and isolation of enzymes from plant source (phosphatase / esterase).
2. Fractionation of proteins by ammonium sulphate and desalting by dialysis.
3. Fractionation of proteins by acetone / pH precipitation (esterase)
4. Partial purification of alkaline phosphatase by ion exchange chromatographic technique.
5. Purification of esterase by gel permeation chromatographic technique.
6. In-gel assay of purified protein by Native-PAGE.
7. Molecular weight determination of purified protein by SDS-PAGE.
8. Isoelectrofocussing of the purified enzyme.

Tutorial 03 : Cancer biology **40 hrs**

Immortalization and transformation of cells: Nomenclature of Different stages and types of cancer, metastasis. Transforming virus, protooncogene, oncogenes, tumor suppressor genes; Rb gene and p53 genes. 14hrs

Apoptosis: Discovery, morphological changes. Caspases and its types. Initrinsic pathway, Extrinsic pathway, mitochondrial regulation and removal of dead cells. Distinguishing apoptotic cells from necrotic cells. Molecular basis of cancer and mechanism of apoptosis. Role of HeLa cells, Hyperactive apoptosis and treatments. 12 hrs

Detection and treatment: Clinical and classical signs of cancer. Detection of cancer. Detection and treatment strategies of BRAC. Chemotherapy (Natural and synthetic drugs) and radiation therapy. 14 hrs

SEMESTER IV

EC05: Molecular Biology - II **45hrs**

Objective

- *To describe the processes of translation in both prokaryotes and eukaryotes at the molecular level*
- *Understand the redundant and universal qualities of the genetic code and how it is used to determine the amino acid sequence of a polypeptide.*
- *To describe how prokaryotes control their gene expression through positive and negative regulatory mechanisms.*

Course outcomes

CC01: To provide a detailed information about prokaryotic and eukaryotic gene expression.
CC02: To understand the positive and negative regulatory mechanisms involved in gene expression.
CC03: To provide an insight to translational regulation of the genes in humans and special emphasis on quantification of the transcripts.
CC04: To enable students to think and apply methods of molecular biology in designing a new product which will aid them in pursuing professional careers.

Translation: Prokaryotic and eukaryotic ribosomes; molecular components, *in vivo* assembly, dissociation of subunits, and polysomes. Three site model of ribosome, peptide bond formation. Initiation of protein synthesis in prokaryotes, Shine-Dalgarno sequence, formation of 30S and 70S initiation complexes. Eukaryotic translational initiation-scanning model, eukaryotic initiation factors, role of eIF4E, F and G. Formation of stable 48S initiation complex, role of eIF1 and eIF1A. Control of translation in bacteria and eukaryotes. Amino acyl-tRNA

synthetases, stop codon suppression, release factors, aberrant termination, non-stop mRNAs, termination of transcription. Mechanism of translational control. Inhibitors of prokaryotic and eukaryotic translation. Post-translational modifications of proteins. 12 hrs

Regulation of gene expression in prokaryotes: Definition of operon, cis and trans acting elements. Lac operon, structure and regulation of lac operon. Anatomy and regulation of galactose, arabinose and tryptophan operons, T attenuation control. Riboswitches. 8 hrs

Regulation of gene expression in eukaryotes: Chromatin structure and its effect on transcription. Effect of histones on transcription activation. Nucleosome positioning, DNase hypersensitive sites and mapping. Histone modifications: Acetylation of histone tails. Identification of histone acetyl transferases (HATs). Chromatin remodeling; Major classes of remodeling complexes; assay of remodeling; ChIP. Mapping and quantifying transcripts; Northern blots; S1 mapping of 5' and 3' ends of transcripts. Quantification of gene expression by measuring protein product. 10 hrs

Methods in molecular biology : Role DNA modifying enzymes – restriction endonucleases, ligases, alkaline phosphatase, polynucleotide kinase. Cloning and expression vectors – pBR322, pUC18, pGEM T, cosmids and phagemids, pET28, TA cloning. cDNA cloning, polymerase chain reaction (PCR), reverse transcriptase PCR, Real time PCR, microarray. 15 hrs

References

1. Molecular Biology of the Cell: Alberts 5th Edition 2007 NCBI Publication
2. Molecular Biology: Robert Weaver 5th Edition, WCB McGraw - Hill
3. Principles of Biochemistry: Lehninger WH Freeman
4. Molecular Biology; David Freifelder, J. (1997) Narosa publishers.
5. Molecular Cell Biology: Lodish 6th Edition, WH Freeman & Company
6. The cell: Cooper 2nd Edition ASM Press
7. Genes IX: Benjamin Lewin Published by Pearson Prentice Hall
8. Cell and Molecular Biology: Gerald Karp
9. Molecular Biology of the Gene: Watson 6th Edition, Pearson Publication
10. Gene Regulation: A Eukaryotic Perspective: David Latchman 5 illustrated, Taylor & Francis, 2005

EC06: Molecular Pharmacology 52hrs

Objective

- *Understand the basic principles of pharmacology (including molecular pharmacology)*
- *Understanding of basic sciences relevant to pharmacology*
- *Process of new drug development*
- *Clinical pharmacology (including clinical pharmacokinetics, individualization of drug therapy, drug use in special categories, adverse drug reactions and drug-drug interactions)*
- *Pharmacogenomics*

Course outcomes

CC01: To Understand the basic principles of Clinical pharmacology (including pharmacokinetics, drug therapy, adverse drug reactions and drug-drug interactions.
CC02: To give an outline and critically appraise the principal steps in drug discovery.
CC03: To explain the rationale for the complete development plan (pharmaceutical, pre-clinical and clinical) according to the proposed therapeutic indication.
CC04: To critically review the issues (including legal, ethical and clinical) involved in the undertaking of clinical research.
CC)5: To analyze the principles of health economics and discuss their application in the development and marketing of medicines.

Basic pharmacology: General concepts of pharmacology, drug categories, drug nomenclature, subdivisions of pharmacology, sources of information about drugs. 4hrs

Approaches to Drug Design: Nature and sources of drugs. Methods of variation, study of the use of biochemical and physiological information involving new drugs. Rational drug design. Selected physiochemical properties like isosterism, steric behaviour, ionization, hydrogen bonding, chelation, oxidation- reduction potential, surface actions. Basic considerations of drug design, de- novo drug design. Prodrug concepts. 14 hrs

Pharmacokinetics: ADME process. Complex of events between drug administration and drug action. Solubility & partition coefficient. Concept of receptors, theories of drug receptor interaction, forces involved in drug receptor interaction. Receptor polymorphism and dimerization and its importance in drug design. 10hrs

Pharmacodynamics: Adverse response to drugs, drug intolerance, drug allergy, tachyphylaxis, drug abuse, vaccination against infection. Mechanism of action of drugs used in therapy of – respiratory system, antimicrobial drugs, cancer chemotherapy, thyroid and antithyroid drugs, insulin and oral antidiabetic drug, antifertility and ovulation inducing drugs. 10hrs

Molecular Pharmacology: Application of molecular pharmacology to drug design. Introduction to cell structure and function. Cell signaling, organization of signal transduction pathway and biosensors. Protein structure prediction and molecular modeling. 8 hrs

Gene Therapy: Gene transfer technologies (viral and non-viral vectors). Clinical application of gene therapy. Disease targets for gene therapy. Pharmacodynamics, pharmacokinetics of peptide and protein drugs and immunogenicity of protein therapeutics. 6hrs

References

1. A guide to chemical basis of drug design by Alfred Burger (John Wiley & Sons).
2. Introduction to the principles of drug design by John Smith and Haywel Williams (Wright PSG).
3. Burgers Medicinal chemistry – The basis of Medicinal Chemistry by Manfred E. Wolff Part – 1 (John Wiley & Sons).
4. Computer assisted Drug Design by Edward. C. Olson (American Chemical Society- ACS symposium series 112).
5. Wilson & Giswold's text book of Organic, Medicinal and Pharmaceutical Chemistry.
6. Goodman and Gilman's – The Pharmacological Basis of Therapeutics – 8th edition (Pergamon Press)
7. Medicinal Chemistry – The role of organic chemistry in drug research by S.M. Roberts and B.J. Price.
8. Principles of Medicinal chemistry by William Foye.
9. Vogel's text book of practical organic chemistry y Arthur I. Vogel (ELBS and Longman).
10. Current protocols in molecular biology by Frederick. M. Ausubel.
11. Human molecular genetics by Tomstracham & Andrew P. Read.
12. Bioinformatics: Genes, proteins & Computers by Christine Orengo.
13. The Cell – A molecular approach, Geoffrey M. Cooper.

EC 07: Biochemical Genetics 52 hrs

Objectives: *The aim of the course is to give students an introduction to the theories of evolution, language and basic concepts of genetics, inheritance of traits, Mendelism and its extensions, basic theory of quantitative inheritance,*

molecular basis of genetics, population genetics techniques, processes of transformation, transduction and conjugation in bacteria and their use in gene mapping etc.

Course outcomes
CC01: To examine and integrate central ideas underlying the evolutionary patterns and processes from the molecular to organism level.
CC02: To investigate the Mendelian and Non-Mendelian inheritance at chromosomal level.
CC03: To employ the scientific method of pedigree analysis to solve problems of human hereditary disorders
CC04: To analyze and explain microbial and human genetic components and inheritance
CC05: To describe human quantitative traits and population genetics and apply its principles to newer situations

Introduction to evolution**:** Abiotic origin of life with reference to Miller's experiment. Classical theories of evolution: Critical review of Lamarckism, Darwinism and mutation theory of de Vries, Dobzhansky, Neo Lamarckism, Neo Darwinism. Modern synthetic theory. Molecular Evolutionary clock. Other concepts of evolution: Goldschmidt's concept of micro- and macroevolution; Gould and Eldredge's punctuated equilibrium hypothesis. Isolating mechanisms, allopatric speciation and sympatric speciation: Basic concepts. 7 hrs

Classical genetics: Pattern of inheritance, Dominant and recessive inheritance, Mendel's contribution. Extensions and modifications of basic principle - Multiple alleles, Lethal alleles, Expressivity, Penetrance, Gene interactions– Epistasis, Inheritance of genes. Non-Mendelian Inheritance – Maternal effect, maternal influence, cytoplasmic inheritance. Sex determination, Sex linked and sex- limited traits. 8 hrs

Pedigree Analysis – Different modes of Inheritance. Application and Genetic testing. 4 hrs

Viral Genetics: Transduction; specialized, generalized and abortive. Fine structure analysis of T-phages; Benzers work, concept of cistrons. 4 hrs

Bacterial genetics: Bacterial chromosome, plasmids; fertility, resistance, colicinogenic and others. Recombination in bacteria. Mechanism of recombination, transposable genetic elements, transformation and conjugation in bacteria. Linkage map of bacterial chromosomes. 6hrs

Human Genetics: Biochemical events occurring during mitosis and meiosis. Chromosome banding, Chromosome mapping based on recombination frequency data. Gene structure in eukaryotic organisms, introns, exons, pseudogenes, gene clusters, spacers, repetitive sequences

and transposons. Organelle genomes. C- value paradox. Overview of human genome project, mapping of human genes; techniques used, assignment of important genes. Transposition in human chromosomes. Chromosomal abnormalities. 12 hrs

Quantitative Genetics**:** Human quantitative traits, discontinuous traits and continuous traits, genetic basis of quantitative variation, Multiple factor hypothesis and analysis of polygenes. Introduction to Statistical methods used, Genotype- Environment Interaction and models for their measurement. Heritability Index Estimation. 7 hrs

Population Genetics: Calculating genotypic and allelic frequencies. Hardy-Weinberg Law – Assumptions, Implications and Extensions. Evolutionary forces affecting allelic frequencies – Mutation, Migration, Genetic Drift and Natural Selection. 4 hrs

References

1. Genetics, Strick Berger, M.W. (1990) 3rd Edn. McMillan.
2. Human Molecular Genetics; Peter Sudbery, (2002) Printice Hall.
3. Introduction to Modern Virology, Primrose and Dimmock (1988), Blackwell Sc.
4. Molecular Biology of the Cell, Alberts et al., (1989) 2nd Edn.Garland Publications
5. Molecular Biology; Current Innovations and Future Trends; Griffin and Griffin, (1995), Horizon Scientific Press.
6. Molecular Biotechnology; Glick and Pasternak, (1998), ASM Press.
7. Molecular Cloning; A Laboratory Manual; Sambrook and Russel [Eds.] (2001) 3rd Ed. Cold spring Harbor.
8. Nuclear Organization; Chromatin Structure and Gene Expression, Roen Van Driel and Arie P. Otte (1997) Oxford University Press.
9. Text Book of Biochemistry with Clinical correlations; Thomas Devlin [Ed.] (1997), Wiley-Liss.
10. The Science of Genetics, George W. Burns and Paul J. Bottino (1989), Maxwell-McMillan.
11. Virology; Heinz Fraenkel-Conrat et al., [Ed.] (1988) Prentice Hall

EC 06: Biotechnology 52 hrs

Objectives

- *To understand the application of scientific and technical advancement in life science for the development of commercial items.*
- *It is a research-oriented science which combines biology and technology. Biotechnology is regarded as the next leading edge in scientific exploration.*
- *Further Biotechnology encompasses studies from outside the area of biology merging subjects like, information technology, chemical engineering, bioprocess engineering, embryology, immunology, virology, health and medicine, agriculture and animal husbandry, seed technology, ecology, soil science, etc.*

Course outcomes

CO1: An understanding of the factual and theoretical basis of Biotechnology on the molecular, cellular, and organism levels.
CO2: Comprehension of and appreciation for the role of Biotechnology in explaining the unity, similarity and diversity of life components with demonstrable understanding of the life hierarchical organizations and their characteristics.
CO3: Knowledge of the basic laboratory tools and biotechnology-related techniques to be able to function successfully within the biotechnology employment sector in areas such as hospital, environmental and forensics laboratories and the pharmaceutical industry.

Restriction endonucleases and DNA modifying enzymes: Restriction enzymes Discovery, classification, properties, and applications. Reactions, application of the following modifying enzymes employed in rDNA technology; DNA- and RNA ligase, Phosphatases and kinases DNase (DNase-I) and RNases (RNase A, H), S1- and Micrococcal nuclease, double and single stranded exonucleases. DNA and RNA polymerases (Klenow fragment), template independent RNA polymerases. Topoisomerase. Linkers and adapters, TA-cloning. 8 hrs

Cloning Vectors: Basic properties of plasmids. Desirable properties of vectors, plasmids as vectors. Directional cloning in plasmid vectors, blunt end cloning in to plasmids. Preparation and transformation of competent *E. coli* electroporation. Screening colonies using X-gal and IPTG (α-complementation), screening by hybridization. Bacteriophage lambda vectors; Insertional and replacement lambda vectors, transfection, *in vitro* packaging, screening recombinant phages**.**

9 hrs

Genomic and cDNA libraries: Outline of methodology for genomic library construction, creation of genomic libraries using lambda and cosmid vectors. Growth, evaluation and storage of genomic libraries; cDNA libraries, methodology, random arrayed and ordered cDNA libraries, screening cDNA libraries; probe selection, hybridization. Screening with antibodies, rescreening and sub-cloning. Characterization of plasmid clones, restriction digestion, southern blot, PCR and sequence analysis. 10 hrs

PCR: Discovery, principle and procedure, variants of PCR – RT-PCR, long PCR differential PCR, and inverse PCR. Application of PCR; Rapid amplification of cDNA ends (5' and 3' RACE), Cloning PCR products, PCR in screening clones, colony PCR, Diagnostic application of PCR. TA cloning. Knockouts. Transgenic vs cloning. 6 hrs

Gene transfer to animal cells: Overview of strategies, transfection methods, phospholipids as delivery vehicles, electroporation and direct transfer, transient and stable transformation, Co-transformation and selection of stable transformants, selectable markers for animal cells. Mammalian plasmid expression vectors, reporter genes. Gene transfer by viral vectors; adeno and baculo virus, retroviral vectors. 7 hrs

Gene transfer to plants: Plant cell culture and protoplast, callus and their manipulations. *Agrobacterium* mediated transformation, Ti plasmid, mechanism of T-DNA transfer, Function of T-DNA genes, high capacity binary vectors, selectable markers for plants, control of transgene expression in plants. Direct DNA transfer to plants; protoplast transformation, particle bombardment, *in-planta* and chloroplast transformation. Plant expression vectors. Application of transgenesis in crop improvement – insect resistance, virus resistance, herbicide resistance. 7 hrs

Bioethics: Ethics in animal experimentation. Ethical issues in human gene therapy and human cloning. Specific principles for chemical evaluation of drugs, herbal remedies and human genetics research, Ethics in food and drug safety. Environmental release of microorganisms and genetically engineered organisms. 5 hrs

References

1. Molecular Cloning; A laboratory manual; Michael R. Green, CSHL Press (2012).
2. Molecular Cell Biology; Lodish et al., 7thEdn. W.H. Freeman and Co (2012)
3. Molecular Biology of the Cell; 7th Edn. Bruce Alberts et al., (2008), Garland Publications
4. Molecular Biology; Robert F. Weaver, McGraw Hill (2012).
5. Principles of Gene Manipulations; 6th Edn. S.B. Primrose, R.M. Twyman, and R.W. Old, Blackwell Science (2012).
6. Gene Cloning and DNA analysis- An Introduction; T. A. Brown, 5th Edition, Wiley-Blackwell Publishing (2006).

9. Molecular biology and Biotechnology; 4th Edn., J.M. Walker and R. Rapley, RSC (2000).
10. Plant Biotechnology and Agriculture; Arie Altman and Paul Hasegawa Academic Press (2011).
9. Principles and Techniques of Biochemistry and Molecular Biology; 7th Edn. Keith Wilson and John Walker (2010).
10. Current Protocols in Molecular Biology; Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. Moore, J.G. Seidman, John A. Smith, Kevin Struhl. John Wiley & Sons

Lab 1 - Molecular Biology

1. Isolation and characterization of genomic DNA from bacteria (*E. coli*).
2. Isolation and characterization of genomic DNA from plant.
3. Isolation and characterization of plasmid DNA from bacteria.
4. Isolation and characterization of total RNA from microbial sources.
5. Spectroscopic determination of melting temperature (Tm) of calf thymus DNA.
6. Restriction digestion and ligation of DNA.
7. Preparation of competent cells and study of bacterial transformation.
8. Study of bacterial conjugation.
9. Phage titration.
10. Amplification of desirable gene by Polymerase chain reaction.
11. Rapid amplification of polymorphic DNA.
12. Southern blotting.

Tutorial 4- Nanobiotechnology **40 hrs**

Objectives: *The aim of the course is to give students an understanding of the basic scientific concepts underpinning nanoscience, the properties of biomaterials used in medicine and research and current frontier developments in nanotechnology both nationally and internationally.*

Unit 1: Introduction to terminology, properties of nanoparticles. Nano-biomimicry with examples. Synthesis of nanomaterials by physical (mechanical milling, laser ablation) and chemical (reduction) methods. Synthesis of nanomaterials by biological methods, Characterization of nanomaterials. 10hrs

Unit 2: DNA nanotechnology – features of self-assembly, DNA origami, applications. Protein nanotechnology – peptide scaffolds, peptide ink, nanopore based sensors. Glyco nanotechnology- applications in bioimaging, sensing, anti-adhesive therapy. Lipid nanotechnology – liposomes, niosomes, nanoemulsions, and solid lipid nanoparticles as carrier systems.

Carbon nanotubes – types, synthesis, functionalization and application. 10 hrs

Unit 3: Cancer diagnostics – properties and applications of quantum dots, carbon dots, computed tomography, magnetic resonance imaging. Cancer therapy – nanomaterials for cancer therapy, theranostics. Tissue engineering – Tools of tissue engineering, applications of nanotechnology in tissue engineering. Artificial cells – various types of cells; capsosomes, applications of artificial RBCs. Organ printing – components of processing, applications, advantages and limitations.

10hrs

Unit 4: Point-of-care diagnostics – types of paper-based diagnostics (dipstick, lateral flow, microPADs). hCG detection system, continuous glucose monitoring system.

Nanopharmacology – slow and sustained release dosage form, ADME evaluation by multi organ micro devices and human on a chip. Drug dispersion, Drug targeting –to respiratory system, brain, eye, neoplastic tissue.

Nanotoxicology – exposure scenarios, genotoxicity, hemocompatibility assays, in vivo assessment of nanomaterial toxicity, 10hrs

References

1. Nanobiotechnology**:** Concepts, Applications and Perspectives, Christof M.Niemeyer, Chad A.Mirkin, (eds.), Wiley-VCH, Weinheim, (2004).
2. Bionanotechnology: Lessons from Nature**,** by: David S. Goodsell, Wiley-Liss (2004)
3. NanoBiotechnology Protocols**,** Sandra J Rosenthal, David W.Wright, Series: Methods in Molecular Biology, (2005).
4. Nano Biotechnology, Horizions Biosciences, K.K.Jain, (2006)
5. Kewal K. Jain , The Handbook of Nanomedicine Humana Press, (2008).

6. Zhang, Nanomedicine: A Systems Engineering Approach" 1st Ed., Pan Stanford Publishing, (2005).
7. Robert A. Freitas Jr., ―Nanomedicine Volume IIA: Biocompatibility, Landes Bioscience Publishers, (2003).