Maharani Lakshmi Ammanni College for Women Autonomous
Affiliated to Bengaluru City University
Accredited by NAAC (IV Cycle) with "A" Grade,
Recognised by UGC under Section 2(f) and 12(b) of the UGC Act 1956
Conferred the Status of 'College with Potential for Excellence' by UGC

Syllabus

for

M. Sc. Biochemistry

Choice Based Credit System **(CBCS)**

I to II Semesters

(With effect from 2023 onwards)

Department of Biochemistry,
mLAC, Autonomous
Bangalore -560 012

August 2023

Proceedings of the meeting of the Board of Studies in Biochemistry (PG) held on 09th Aug, 2023 in the Department of Biochemistry, mLAC, Bangalore -560012.

The meeting of the Board of Studies in Biochemistry (PG) for restructuring I and II Semester M.Sc Biochemistry syllabus was held on Wednesday, the 09th Aug, 2023 at 10.30 am to approve the M.Sc. CBCS I and II Semester Biochemistry syllabus. The Chairman welcomed the members, the draft syllabus approved by the Departmental Council was placed before the board. After day-long scrutiny, the board approved the M.Sc. Biochemistry CBCS syllabus with incorporation of appropriate modifications. The Chairman thanked all the members for their active participation and valuable inputs.

Members present:

BOS panel (External)	**BOS panel (Internal)**
1. Dr.Chandrakant S Karigar (University nominee)	**1. Dr. Kushalatha M (BOS Chairman)**
2. Dr. G.J. Sathisha (Subject expert)	**2. Dr. Kamala A (member)**
3. Dr. Vasantha Kumar Bhaskara (Subject expert)	**3. Ms. Vani K. M (Ph. D) (member)**
4. Dr. Manjula J (Industry expert)	**4. Ms. Usha T (Ph. D) (member)**
5. Ms. Chitra Gopinath (Alumnus)	**5. Dr. Pradeep Kaushik(member)**
	6. Dr. Umesh HR (member)
	6. Ms. Jayashree N. S (member)

Sd.
Chairperson, Dept. of Biochemistry
mLAC, Bangalore

Name of the Course: **M. Sc. Biochemistry**

Duration of the course: **Two years**

Eligibility: Candidate must have secured 40% in aggregate and studied Chemistry (or) Biochemistry as one of the cognate subjects securing 50% marks at B.Sc. level, and studied Biology at PUC (or) 10 + 2 level.

Intake: 20

Admission: As per the prevailing University regulations.

SCHEME OF STUDY AND EXAMINATION

I & II SEMESTER M. Sc. BIOCHEMISTRY COURSE (Autonomous)

First Semester							
Paper Code	**Title of the paper**	**Contact hours**	**Exam. hours**	**Marks**			**Credits**
				IA	**Exam**	**Total**	
BCT – 101	Biophysical and Bio -organic chemistry	4	3	30	70	100	4
BCT – 102	Biomolecules	4	3	30	70	100	4
BCT – 103	Clinical Biochemistry	4	3	30	70	100	4
BCT – 104	General Physiology	4	3	30	70	100	4
BCS – 105	Nutrition and Toxicology	3	3	30	70	100	2
BCP – 106	General Biochemistry	8	4*	30	70	100	4
BCP – 107	Clinical Biochemistry	8	4*	30	70	100	4
	Total					700	26

Second Semester							
Paper Code	**Title of the paper**	**Contact hours**	**Exam. hours**	**Marks**			**Credits**
				IA	**Exam**	**Total**	
BCT – 201	Enzymology	4	3	30	70	100	4
BCT – 202	Analytical Biochemistry I	4	3	30	70	100	4
BCT – 203	Immunology	4	3	30	70	100	4
BCT – 204	Metabolism I	4	3	30	70	100	4
BCS – 205	Microbiology	3	3	30	70	100	2
BCP – 206	Immunochemical Techniques and Bioinformatics	8	4*	30	70	100	4
BCP – 207	Enzymology	8	4*	30	70	100	4
	Total					700	26

Scheme for Continuous Evaluation

Theory Paper (each)

Tests*: C1	15 Marks
Assignment: C2	10 Marks
Seminar C3:	05 Marks
Total:	**30 Marks**

*Two tests will be conducted and average of marks from two tests shall be computed for continuous evaluation

Practical (each)

Practical Tests*:C1	20 Marks
Class Record: C2	10 Marks
Total:	**30 Marks**

*Two tests shall be conducted and average of marks from two tests shall be computed for continuous assessment.

Question paper pattern for End semester theory Examination

Time: 3hrs **Max. Marks: 70**

Instruction to the students: 1) The question paper has three parts (Part A,B & C)

2) Answer all the parts

3) Draw diagrams and write chemical equations **wherever** necessary

Part A, Question number I, shall have 12 sub questions 1 to l2 of two marks each, and the student has to answer any **Ten** of them. **(2X10=20)**

Part B, Question No. II, Shall have 7 questions; student has to answer any five question each carries 4marks **(5X4=20)**

Part C, Question No. III, Shall have 7 questions; student has to answer any five question each carries 6marks. **(5X6=30)**

Question paper pattern for end semester Practical Examination

Time: 4h **Max. Marks: 70**

1. Give the principle and procedure for ….	10
2. Perform any one of the experiments listed in the syllabus for the semester.	35
3. Viva-Voce.	15
4. Practical record.	10

BCT – 101: Biophysical and Bioorganic Chemistry

4 units (52 hrs)

Unit 1: Biophysics of water

Physicochemical properties of water, structure of liquid water and ice. Effect of solutes on colligative properties of water. Importance of water in biological system with special reference to the maintenance of native structure of biological molecules. Ionization and ionic product of Water. Biological relevance of pH and pKa, determination of pKa of weak acid.

Buffers, buffer action, and buffer capacity. Henderson–Hasselbalch equation, Preparation of buffers. Importance of buffers in biological systems (cytosol and blood). **7hrs**

Unit 2: Thermodynamics

First law of thermodynamics, basic concepts of entropy and second law of thermodynamics, free energy changes, standard free energy change and its relation to equilibrium constant. Oxidation-reduction reactions in biological systems. **5hrs**

Unit 3: Stereochemistry

Optical isomerism, chirality, symmetry elements, enantiomers, diastereomers, DL and RS notations, racemization , resolution, stereoisomerism and geometrical isomerism, cis – trans and E – Z conventions, Spiranes. **5hrs**

Unit 4: Mechanism of Bio-organic reactions

Introduction, kinetic and non kinetic. Homo and heterolytic cleavage. Structure and reactivity of carbocation (C^+) , carbanion (C^-) and carbon free radical ($C^\cdot$) characteristic aspects of ionic, radical and concerted reactions, substitution, nucleophilicity and basicity, leaving group effects, solvents effects. addition, elimination and rearrangements. Saytzeff and Hoffman eliminations, dehydration of alcohols, pyrolytic eliminations. Energy profiles of reactions, transition state theory, kinetically and thermodynamically controlled reactions. Reactions SN^1,SN^2, SN^ineighbouring group participation. E_1, E_2 ,E_{1cb}, Curtin Hammett principle. Electrophilic addition to C=O, aldol condensation and related condensation. Michael addition, Cannizaro and Manich reactions. Esterification and hydrolysis. **15 hrs**

Unit 5: Rearrangements

Migration to electron deficient C, N and O; Wagner Meerwein, Pinacol, Beckmann, Hoffmann, Bayer-Villiger reactions, allylic rearrangements. Benzilic acid rearrangement. **6 hrs**

Unit 6: Heterocyclic systems

Occurrence in biological systems, structure and properties of furan, pyrrole, Indole, thiazole, imidazole, pyridine, pyrimidine, purine, quinone, pteridine and isoalloxazine containing biomolecules. **7 hrs**

Unit 7: Bioinorganic chemistry

Ligand field theory of complexes, stability of complex ions in solution, kinetics and mechanism of reactions of complexions. Ligand replacement reactions and electron transfer reactions of organometallic moieties of biological macromolecules (cytochromes, chlorophyll and hemoglobin). **7hrs**

References

1. Physical Biochemistry. Kansal Edward Van Halde. Prentice Hall.
2. Physical Biology of the Cell, 2nd Edn. Rob Phillips, Jane Kondev, Julie Theriot, Hernan Garcia, Garland Publishers (2012).
3. Bioinorganic Chemistry; Ei-Ichiro Ochiai, Elsevier (2008).
4. Physical Biochemistry. David Frefielder. 2nd Edn. W.G.Freeman and Co ( )
5. Organic Chemistry. Vol.I. Fundamental principles. I. L .Finar. 6th Edn. ELBS
6. Inorganic Biochemistry. G.L. Eicharn. Elsevier.
7. Organic Mechanisms, Peter Sykes, Longman, (1977).
8. Biochemical Calculations, Irwin H. Segel (1976) 2nd Ed. John Wiley and Sons.
9. Introduction to Biophysical Chemistry, Bruce Martin
10. Organic Chemistry. R.T. Morrison and R.N.Boyd. 6th Edn. Prentice Hall, India.
11. Lehninger- Principles of Biochemistry; DL Nelson and MM Cox [Eds), 6th Edn. Macmillan Publications (2012).
12. Principles and techniques of practical Biochemistry. K.Wilson and J. Walker. 4thEdn. Cambridge University press (2012).
13. Chemistry- An Introduction to General, Organic and Biological Chemistry, 7th Edn. Karen C. Timberlake, Benjamin Cummings, (1999).
14. Physical Chemistry of Macromolecules, C. Tanford.
15. Molecular Cell Biology Baltimore et al., Scientific American Publication (1995).
16. Reaction Mechanisms at a glance, ed. M. Moloney, Blackwell Science (2000).

BCT-102 : Biomolecules

4 units (52 hrs)

Carbohydrates

Configurational and conformational aspects of carbohydrates. Properties of monosaccharides. Glycosaminoglycans - Structure and biological importance of Hyaluronic acid, heparin, chondroitin-4-and 6-sulfate, Dermatan sulfate, Keratan sulfate. Proteoglycans, cardioglycosides and bacterial cell wall components. Structure elucidation of polysaccharides (starch, glycogen and cellulose). Glycoproteins; structure and biological functions of *N*-and *O*-linked glycoproteins. Antifreeze glycoproteins, Methods of structural degradation of oligosaccharides Methylation, Periodate oxidation. Lectins – characteristics and functions in biological system. Blood group antigens. **10 hrs**

Lipids

Chemistry of lipids, classification and properties; Structure, nomenclature and properties of glycerophospholipids, sphingolipids, glycolipids and sterols; hydrophobic and hydrophilic interactions of lipids (mono, bi-layer,micelles and liposomes). *Liposomes;* preparation, properties and application in membranes. Non bilayer lipids and their role. Eicosanoids – prostaglandins, thromboxanes, leukotrienes & leptin **7 hrs**

Amino acids and Proteins

Classification and structure of amino acids, acid – base properties of amino acids. Non–protein amino acids, UV light absorption property of amino acids. Peptides and proteins –classification. Naturally occurring peptides. Peptide synthesis– reactive ester method and modified Merrifield solid phase synthesis; Structural organization of proteins.

Elucidation of primary structure of proteins – Determination of amino acid composition, end group analysis, cleavage by enzymes and chemicals, separation of fragments. Methods of protein sequencing and reconstructing the protein sequence. Assignment of disulfide bonds.

Secondary structure: α – helix and other types of helices, β – pleated sheet, irregular, turns, loops and triple helical structures. Ramachandran plot, Helix stabilizing and destablizing amino acids. Structure of fibrous proteins: α keratin, silk fibroin and collagen. Motifs (super secondary structure – triose phosphate isomerase, concanavalin and Rossmann fold) and domain structure(glyceraldehyde-3- phosphate dehydrogenase).

Tertiary structure: Forces stabilizing tertiary structure of proteins. Protein denaturation and renaturation.– Anfinsen's experiment. Structure of ribonuclease, lysozyme, myoglobin and chymotrypsin.

Quaternary structure and symmetrystructure and function of myoglobin and hemoglobin.

Structure and function of membrane proteins. **22 hrs**

Protein folding pathways

Protein dynamics – kinetics of protein folding and disulfide bond formation, molecular chaperones and protein disulfide isomerase. Disease related to protein folding – Alzheimer's and mad cow disease. **5 hrs**

Nucleic Acids

Structure of nucleic acids– primary, secondary and tertiary structure of DNA. Structure of DNA, m RNA and t-RNA. Conformational forms of DNA, Models-supercoils, cruciform, single stranded and satellite DNA. Isolation, fractionation and characterization of nucleic acids. Properties of nucleic acids in solution, melting point of DNA, buoyant density and UV absorption. Chemical synthesis of oligonucleotides (phosphate and phosphite method). Nucleic acid sequencing – Maxam and Gilbert, Sanger's and pyro sequencing methods. **8 hrs**

References

1. Lehninger- Principles of Biochemistry; DL Nelson and MM Cox [Eds), 6th Edn. Macmillan Publications (2012).
2. Biochemistry VI Edition; Jeremy M Berg, John L Toymoczko and Lubert Stryer, W H Freeman and Co. (2006).
3. Physical Biology of the Cell, 2nd Edn. Rob Phillips, Jane Kondev, Julie Theriot, Hernan Garcia, Garland Publishers (2012).
4. Biochemistry; Voet, D. and Voet, J.G. [Eds.] 3rd Ed. Jhon Wiley and sons, (1999).
5. Biochemistry; David Rawn, J, Neil Patterson Publishers (1989).
6. Complex Carbohydrates, Sharon, N. Addison Wisely, (1975).
7. Methods of Enzymatic Analysis; Berg Meyer Vol. 1-X, (1974).
8. Nucleic acid Biochemistry and Molecular Biology, Mainwaring et al., Blackwell Scientific (1982).
9. Principles of Biochemistry; Smith et al., McGarw Hill (1986).
10. Proteins Structures and Molecular Properties 2nd Edn. Thomas E. Creighton, W H Freeman and Co. (1993).
11. Principles of Protein Structure, Function, & evolution, Dickerson & Geis 2nd Ed. Benjamin-Cummings (1983).
12. Biochemistry Ed. Donald Voet & Judith G. Voet, John Wiley & Sons, Inc.(2010).
13. Practical Biostatistics; Mendel Suchmacher and Mauro Geller, Academic Press (2012).

14. Harper's Illustrated Biochemistry; 27th Edn. Robert K. Murray, Daryl K. Granner, Victor W. Rodwell _ The McGraw-Hill (2006).
15. Lipid Biochemistry; 5th Edn. Michael I. Gurr, John L. Harwood and Keith N. Frayn, Blackwell Science (2002).
16. Biochemistry of Lipids, Lipoproteins and Membranes; 5th Edn. Dennis E. Vance and Jean E. Vance, Elsevier (2008).

BCT-103: Clinical Biochemistry

4 units (52 hrs)

Approaches to clinical biochemistry

Concepts of accuracy, precision, sensitivity and reproducibility. Automation in clinical biochemistry laboratory, Quality control- Principle and applications.
Specimen/sample collection, processing and storage of Blood, Urine, Stool, CSF and sputum.
Composition, examination and clinical significance of Stool, CSF and Amniotic fluid **6 hrs**

Blood

Blood Composition – Cellular and non-cellular; functions, Hemopoiesis, Haemostasis and Thrombosis, Blood coagulation - mechanism and regulation, Fibrinolysis. ESR- its determination and importance in disease. Bleeding Time, Clotting Time, Clot retraction and lysis. Blood groups (ABO and MNS system of blood grouping) and Rh factor, Blood gas analysis. Serum electrolytes Plasma proteins- profile in health and diseases. **7 hrs**

Diagnostic Enzymology

Enzymes as markers in the diagnosis of diseases. Diagnostic enzymes,Clinical significance of cholinesterases, alkaline and acid phosphatases, LDH, CPK, SGOT and SGPT, Amylase**.** Enzyme pattern in diseases- Myocardial infarction, hepatobiliary diseases. Enzymes in inborn errors of metabolism – Phenyl ketonuria, alkaptonuria, albinism, Hartnup's disease,Galactosemia, Tay sach's disease, Niemann Pick's disease, Hunter's syndrome, Lesch Nyhan syndrome. **7 hrs**

Diagnostic Endocrinology

Hormones as markers in the diagnosis of diseases. Clinical significance of pituitary, thyroid, adrenal and gonadal hormones. Diabetes Mellitus and Calcium metabolism and its deficiency disorders **6 hrs**

Biochemical investigations in kidney disorders

Kidney profile in health and disease. Urine analysis for normal and abnormal constituents, Assessment of renal function-clearance tests and their importance in assessment of kidney functions. Tubular Function tests. Laboratory investigations of kidney disorders- UTI, kidney stones, Nephritis, Urolithiasis, Uremia, Hyporuricemia. Dialysis and its types. **5 hrs**

Biochemical investigations in Liver disorders

Formation of bilirubin, Clinical importance of bilirubin, urobilinogen, bile acids. Jaundice: pre-hepatic, hepatic, post hepatic.
Liver function tests (LFT) and their clinical significance in the diagnosis of liver diseases. Biochemical indices of hepatobiliary diseases, Hepatitis, Cholestasis, Cirrhosis; Lipid profile.
Gall stone- Analysis and clinical significance. **5 hrs**

Gastro-intestinal profile
Collection. Gastric function tests (gastric juice analysis). Malabsorption syndromes. **3 hr**

Hemodynamic disorders

Thrombosis- DVT and Infarction; Embolism - Pulmonary Thrombo-embolism, systemic thrombo embolism, Fat Embolism, Air Embolism, Amniotic Fluid Embolism.
Edema- Hyperemia,Shock - Septic shock **6 hrs**

Medical Instrumentation

Principle and applications of Blood gas analyser, cell counters, Ventilators, Nebulizers; Humidifiers, Spirometer, Pace maker, Angiography, Pulse oximeter, Reflexion oximetry, ECG, Color Doppler, Echocardiogram, and Heart Lung machine, CT,MRI.. **7 hrs**

References

1. Harper's Biochemistry
2. Fundamentals of clinical chemistry – Teitz, W.B.Saunders company, 1994
3. Practical clinical biochemistry, volume I and II, 5th edition – Varley et.al., CBS Publishers, 1980.
4 . Clinical chemistry in diagnosis and treatment 6th edition – Mayne, ELBS Publications,1994
5. Teitz text book of clinical biochemistry 3rd edition – Burtis et al., William Heinmann medical books, Ltd., 1999
6. Clinical biochemistry – Metabolic and clinical aspects, Pearson Professional Ltd.1995
7. Clinical chemistry 5th edition – Mosby, Marshall, 2004
8. Clinical chemistry – principles, procedures and correlations, Bishop, Lipppincott, 2000

BCT 104: General Physiology

4 units (52 hrs)

Tissues

Formation of different kinds of tissues from primary germ layers. Types and functions of epithelial tissue, intercellular junctions. Connective tissue – extra cellular matrix, Collagens – types, composition, structure and synthesis, Elastin, fibronectins, and other proteins of the extra-cellular matrix. Basal lamina; laminins and associated proteins and their functions. **6 hrs**

Cytoskeleton and Cellular dynamics

Microfilaments; Assembly and polymerization of Gactin, role of ThymosinB4, Profilin and Cofilinin polymerization, structural and functional property of Factin, Capping proteins and assembly of actin filaments, branched and unbranched filament assemblies, intracellular cellular movement and actin polymerization, use of toxins in study of actin dynamics. Role of cross-linking and adaptor proteins in actin bundling and membrane association.

Structure and organization of microtubules; dynamics of microtubules, assembly by MTOC, dynamic instability, tubulin polymerization as target of drugs. Side and end-binding proteins, capping and severing proteins. *Kinesins and dyneins;* vesicular transport along microtubule, role of kinesin-1 and dynein motors in organelle transport. Role of microfilaments and microtubules in cell migration.
Intermediate filaments; Assembly and tissue specific expression, dynamic nature of intermediate filaments, diseases associated with Lamins and Keratins defects. **7 hrs**

Nervous System

Types and structure of neuron.Myelin sheath; composition and function. Resting membrane and action potential. Nernst and Goldman equations. Mechanism of initiation and propagation of action potential – voltage gated ion channels, ionophores and toxins in study membrane transport. Design and use of Patch Clamp in measuring membrane potential. Neurotransmitters and receptors; synaptic transmission, post synaptic potentials. Outline and functions of autonomic and central nervous systems. **6 hrs**

Muscular System

Ultra structure of smooth, skeletal and cardiac muscle fibers. Contractile and other proteins of muscle. Energy metabolism in muscle; Phosphagens, neuromuscular junctions, excitation of striated muscles. Organization of sarcolemma, transverse tubular system and sarcoplasmic reticulum, mechanism of muscle contraction. Regulation of contraction in striated and smooth muscle. Calmodulin and its regulatory role, muscular dystrophies. **6 hrs**

Digestive System

Secretion, regulation of secretion, composition and functions of saliva, gastric, pancreatic and intestinal juices and bile. Gastrointestinal hormones. Digestion, absorption and transport of carbohydrates, proteins, lipids, nucleic acids and vitamins. Liver – structure and functions. Detoxification mechanisms. **5 hrs**

Cardio – vascular System

Systemic and pulmonary circulation. Structure of blood vessels. Regulation of cardiac activity. Blood volume, blood pressure. Plasma composition and functions of plasma liproproteins. Mechanism of blood clotting, role of role of vitamin K, clot dissolution, anti-clotting factors, Formation, counting and functions of erythrocytes, leukocytes and thrombocytes. Lymph, Cerebrospinal fluid (CSF); composition and analysis in diagnosis. **6 hrs**

Respiratory System

Mechanics and regulation of respiration, pulmonary and alveolar ventilation and its control, transport of respiratory gases, Bohr's effect, chloride shift, respiratory mechanism of acid-base balance. **5 hrs**

Excretory System

Mechanism of urine formation and composition of urine. Urine analysis for abnormal constituents. Nephritis and nephrosis. Kidney hormones. Regulation of acid -base electrolyte and water balance. Respiratory and metabolic acidosis and alkalosis. **5 hrs**

Endocrine system

Hormones, feedback regulation, biosynthesis, storage, secretion, Circulation in blood. Degradation and peripheral transformation. Receptors and the mechanism of hormone action. Measurement of hormones and receptors. Disorders of endocrine system. **6 hrs**

References

1. The Cell, Copper, Geoffery, M., Oxford University Press, (2001)
2. Text Book of Biochemistry with Clinical correlations; Thomas Devlin [Ed.](1997), Wiley Liss.
3. Lehninger- Principles of Biochemistry; DL Nelson and MM Cox [Eds), 6th Edn. Macmillan Publications (2012).
4. Principles of Human Physiology; 4th Edn. Cindy L. Stanfield Pearson, (2010).
5. Principles of Biochemistry: Smith et al., [Ed.] (1986) McGraw Hill.
6. Principles of Biochemistry: General Aspects, Smith et al., [Ed.] (1986) McGraw Hill.
7. Human Biochemistry, Orten and Neuhans , 10th Edn. Mosbey International, (1983).
8. Review of Medical Physiology, Gannong, W.F.15th Edn., Maruzen Asial, (1991).
9. Human Physiology: The mechanisms of Body functions. A.J. Vander, et. Al.,(1985) McGraw-Hill.
10. Molecular Cell Biology, Baltimore et. al. (1995) Scientific American Publication.
11. Cellular Physiology of Nerve and Muscle. Gary G Mathew (1998) Balckwell Scientific Inc.
12. Harper's Review of Biochemistry, Murray et. al., (1997) 24th Edn., Lange
13. Molecular Biology of Cell; Albertis et. al. (2002) Garland Science.
14. Biochemistry Ed. Donald Voet & Judith G. Voet, John Wiley & Sons, Inc. (2010).
15. Mammalian Biochemistry; White, Handler and Smith, McGraw-Hill, (1986).

BCS- 105: Nutrition and Toxicology

3 units (39 hrs)

Basics of Nutrition

Role of macro and micro nutrients, proximate analysis of foods, chemical and biological analysis of nutrients. Methods of determining energy value of foods, calorimetry, physiological fuel value, high and low calorie diets. Basal metabolic rate (BMR) factors affecting BMR, specific dynamic action of foods. RDA. Water metabolism- Distribution in body, water balance, and its significance. **5 hrs**

Carbohydrates

Dietary sources, Lactose, Glucose, Fructose intolerance; Dental caries, Artificial sweeteners. Role of dietary fiber in health and disease, Disorders related to carbohydrate metabolism. Glycemic index of foods and its uses. **3 hrs**

Proteins

Evaluation of nutritive value of dietary protein, PER, BV, essential amino acids nutritional classification of proteins, supplementary value of proteins, protein calorie malnutrition Kwashiorkar and Marasmus. **3 hrs**

Fats

Sources, invisible fat, essential and non essential fatty acids, PUFA. Role of lipoproteins and cholesterol, triglycerides in health and disease. **2 hrs**

Vitamins

Fat soluble and water soluble vitamins, pro-vitamins, anti-vitamins, dietary sources, daily requirements, function and deficiency symptoms of B and C vitamins and fat soluble vitamins, hypervitaminosis vitamin - like compounds.

Recommended dietary allowances – special nutrition for infants, children, during pregnancy, lactation and old age. Nutrition for diabetes and cardiovascular disease patients. Wellness diets, fitness diets, obesity and BMI. Regulation of food intake: role of hunger and satiety center. **5 hrs**

Food Additives and fortification

Types of food additives, Fortification and FDA recommendations and its implications. **2 hrs**

Nutraceuticals and functional foods

Scope, sources and future prospectus of Nutraceuticals. Role of isoprenoids, flavonoids, carotenoids, tocotrienols, lecithin and terpenoids. **2 hrs**

Nutrition in various age groups

Physiological adjustments, Nutritional requirements, Effect of malnutrition, and special needs and nutritional problems in Pregnancy, Lactation, infancy, preschool, adolescent, young adults and elderly adults. **3 hrs**

Oxidative stress and Antioxidants

Free radicals: definition, formation in biological Systems. Natural anti-oxidants, defense against free radicals. Role of free radicals and antioxidants in health and disease. Determination of free radicals, lipid peroxides and antioxidants. Antioxidant enzymes and their role. **4 hrs**

Toxicology

Introduction to general toxicology. Classification and ramification in toxicology. Toxicants: Animal and plant toxins, Exposure; Routes of exposure ; Organism environment interaction, Absorption and distribution of toxicants.

Toxicity- Factors influencing Dose response relationship–IC50, LD50, ED50, NOEL. Reversibility and sensivity. Xenobiotics and endogeneous substances. Detoxification enzymes. Mutations- genotoxicity, Ames test. Carcinogenic toxins. Cytotoxicity: methods to test toxicogens, Diagnosis of toxic effects in liver and kidney. Metal toxicity–Arsenic and lead. Hazard identification: Risk assessment, Risk prediction and management. **10 hrs**

References

1. Biochemistry Ed. Donald Voet & Judith G. Voet, John Wiley & Sons, Inc.(2010).
2. Lehninger- Principles of Biochemistry; D.L.Nelson and M.M. Cox, 6th Edn. MacMillan Publications (2012).
3. Biochemistry Ed. Donald Voet & Judith G. Voet, John Wiley & Sons, Inc.(2010).
4. Nutrition: Science and Applications, 3rd Edn. Lori A. Smolin, Mary B. Grosvenor, Wiley (2013).
5. Introduction to Human Nutrition, 2nd Edn. Michael J. Gibney, Susan A. Lanham-New, Aedin Cassidy, Hester H. Vorster, Wiley-Blackwell (2009).
6. Nutrition: Everyday Choices, 1st Edition; Mary B. Grosvenor, Lori A. Smolin Wiley (2006).
7. Bioactive Food as Dietary Interventions for Liver and Gastrointestinal Disease; Watson Elseveir (2012).
8. Nutrition and Metabolism, 2nd Edn., Lanham S, Mac Donald I and Roche H. The Nutrition Society, London, UK, (2012).
9. Introduction to Human Nutrition, 2nd Edn., Gibney M, Lanham S, Cassidy A and Vorster H.The Nutrition Society, London, UK, (2012).
10. Public Health Nutrition. Gibney M, Margetts B, Kearney J and Arab L. The Nutrition Society, London, UK, (2012).
11. Nutritional Biochemistry, Patricia Trueman, MJP publishers (2007)
12. Nutrition 2nd edition, Paul Insel, R.Elaine Turner, Don Ross. Jones and Bartlett publishers (2004).
13. Understanding Nutrition 9th edition. Eleanor Noss, Whitney, Sharon Rady Rolfes. Peter Marshall publisher (2002)

BCP – 106: General Biochemistry (4 Credits)

1. Preparation of buffers; Acetate, phosphate and Tris- HClbuffer.
2. Determination of saponification number and acid value of oils and fats.
3. Determination of iodine number and peroxide value of oils and fats.
4. Determination of pka of weak acids and amino acids by pH metric titration.
5. Hydrolysis of starch / glycogen and estimation of its purity by H.J. method.
6. Hydrolysis of starch / glycogen and estimation of its purity by Somogy's method.
7. Analysis of hardness of water: estimation of calcium and magnesium by EDTA method.
8. Determination of pI of casein from milk.
9. Verification of Beer lambert's law.
10. Estimation of reducing sugars (lactose in milk) by DNS method.
11. Estimation of protein by Lowry's method.
12. Estimation of inorganic phosphate by Fiske-Subbarao method.
13. Estimation of DNA by Diphenylamine method.
14. Estimation of RNA by Orcinol method.

BCP – 107: Clinical Biochemistry (4 Credits)

Analysis of Blood and Urine for diagnostic investigations

1. Estimation of glucose by Folin Wu method/Dubosky's method.
2. Estimation of glucose by glucose oxidase method.
3. Estimation of cholesterol by Zack's method.
4. Estimation of haemoglobin by Wong's method
5. Estimation of urea in blood by Diacetylmonoxime method.
6. Estimation of serum calcium by Clark and Collips method.
7. Determination of A/G ratio by Biuret method.
8. Analysis of SGOT-SGPT (AST, ALT) / creatine kinase / acid or alkaline phosphatase.
9. Qualitative analysis of Urine sample for normal and abnormal constituents.
10. Determination of titrable acidity of urine.
11. Estimation of uric acid in serum and urine by Caraway's method
12. Estimation of creatinine and creatine in serum and urine by Zaffe's method.
13. Estimation of urea in urine by Nesslerization method (Urease method).
14. Determination of urine Chloride by Volhard-Arnold method.
15. Estimation of serum Bilirubin.

II SEMESTER M. Sc. BIOCHEMISTRY

BCT-201: Enzymology

4 Units (52 Hrs)

Introduction to Enzymes

Nomenclature and classification of enzymes. Specificity and active site. Fundamentals of enzyme assay – enzyme units, coupled kinetic assay. Enzyme localization, extraction and purification of enzymes, Criteria of purity of enzymes. Principles of enzymatic analysis- End-point method, Kinetic method and Immunoassay methods.
Monomeric and oligomeric enzymes- Monomeric enzymes; serine proteases, zymogen activation, multifunctional enzymes, oligomeric enzymes and multi- enzyme complexes. **5 hrs**

The investigation of active site structure

The identification of binding sites and catalytic sites–trapping the E-S complex, use of substrate analogs, enzyme modification by treatment with proteolytic enzymes, photo – oxidation and chemical modification of amino acid side chains (cys, met, his, ser, asp, glu, lys, and tyr). Affinity labeling studies (Chymotrypsin, triose phosphate isomerase) and super reactive amino acid chains (chymotrypsin and glutamate dehydrogenase). Site directed mutagenesis. Investigation of the 3-D structural of active sites of lactate dehydrogenase, trypsin, elastase and triose phosphate isomerase. **6 hrs**

Enzyme catalysis

Chemical nature of enzyme catalysis -General acid-base catalysis, electrostatic catalysis, covalent catalysis, intramolecular catalysis and enzyme catalysis.
Mechanisms of action of the following enzymes- lysozyme, ribonuclease, lactate dehydrogenase serine proteases (chymotrypsin, trypsin, elastase), sulphydryl enzymes (papain and alcohol dehydrogenase) multi- enzyme complexes. (Pyruvate dehydrogenase complex). Metal– activated and metallo-enzymes (mechanism of action of pyruvate kinase, creatine kinase, superoxide dismutase & carboxypeptidase – A). Synzymes and Abzymes **7 hrs**

Coenzymes

The mechanistic role of the following coenzymes in enzyme catalyzed reactions – nicotinamide nucleotides, flavin nucleotides, pyridoxal phosphate, coenzyme-A, lipoic acid, thiamine pyrophosphate, biotin, tetrahydrofolate and coenzyme B12. **5 hrs**

Kinetics of enzyme-catalyzed reactions

Law of mass action and order of reaction, use of initial velocity, Methods used for investigation of the kinetics of enzyme-catalyzed reactions- initial velocity studies, rapid reaction techniques and relaxation technique. Enzyme kinetics of single substrate reactions – Michaelis-Menten and Briggs and Haldane theory (rapid equilibrium and steady state theory). Kinetic data evaluation-linear transformation of Michaelis-Menten equation. Pre-steady state kinetics. Haldane relationship for reversible reactions. King-Altman procedure for deriving the rate equation.

Effect of pH & temperature on enzymatic reactions, Arrhenius plot, determination of activation energy. **8 hrs**

Enzyme Inhibition

Types of reversible inhibitors; competitive, non-competitive, uncompetitive, and mixed inhibitors. Partial inhibition, substrate inhibition and allosteric inhibition.Irreversible inhibition and suicidal inhibition. **7 hrs**

Kinetics of bi- substrate reactions

Sequential mechanism, compulsory order and random order mechanism, non-sequential mechanism, ping pong mechanism, distinction between different kinetic pathways using primary and secondary plots. Inhibition studies in the characterization of bi-substrate reactions. Investigations of reaction mechanisms using isotopic exchange at equilibrium. **5 hrs**

Allostery of enzyme action

Binding of ligands to proteins, Co-operativity, the Hill equation, Adair equation, Scatchard plot and equilibrium dialysis techniques. *Sigmoidal kinetics:* MWC and KNF models. Significance of sigmoidal behavior. Allosteric enzymes and metabolic regulation taking ATCase as an example. **5 hrs**

Enzyme Application:

Industrial application of carbohydrates, proteolytic enzyme, lignocellulose degrading enzyme, pectin and pectic enzyme. Applications of enzymes in food and allied industries: leather, textile, detergent, paper industries. Immobilization of enzymes methods and applications. **4 hrs**

References

1. Fundamentals of Ezymology; 3rd Edn. Nicholas C. Price and Lewis Stevens, Oxford University Press (2012).
2. Enzymes; Trevor Palmer, East – West Press Pvt. Ltd., Delhi (2004).
3. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis; Robert A. Copeland , Wiley-VCH Publishers (2000).
4. Enzyme Kinetics and Mechanism; Paul F. Cook, W. W. Cleland, Garland Science (2007).
5. Biochemical Calculations, Irwin H. Segel (1976) 2nd Ed. John Wiley and Sons.
6. Methods in Enzymology; Colowick S.P. et al., Vol. 152, Academic Press, (1987).
7. Methods of Enzymatic Analysis; Berg Meyer Vol. 1-X, (1974).
8. Basic Biochemical Laboratory Procedures and Computing, R. Cecil Jack (1995) Oxford University.
9. Enzyme Kinetics; Roberts, D.V. (1977), Cambridge University Press.
10. The Enzymes; Boyer, Academic Press, (1982).
11. Enzyme Kinetics; Irwin H. Segel (1976) Interscience-Wiley.
12. Enzyme Kinetics; the Steady state approach; Engel, P.C. (1981) 2nd Edn. Champman and Hall.
13. Nature of Enzymology; Foster, (1980), Croom Helm.
14. Principles of Enzymology for Food Sciences; Whitaker, Marcel Dekker (1972) Academic Press.
15. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry; Trevor Palmer (Edn) Horwood Chemical Science Series.

16. Introduction to Enzyme and Co-enzyme Chemistry. Ed. T. Bugg, (2000), Blackwell Science.
17. An Introduction to Enzyme and Coenzyme Chemistry; Timothy B. Bugg, (1997) Jones and Bartlett publishers.
18. Lehninger Principles of Biochemistry; D.L.Nelson and M.M. Cox, 6th Edn. MacMillan Publications (2012).
19. Principles of Biochemistry; Smith et al., Ed. McGraw Hill,(1986).

BCT-202: Analytical Biochemistry I

4 Units (52 hrs)

Overview of Biochemical Investigations

Basic equipments, methods, and safety considerations in animal cell culture. Types of animal cells and their characteristics in culture, culture media and common animal cell lines for laboratory investigation. Plant cell culture, media for plant cell culture, potential of plant cell culture in biochemical investigations.
Characteristic features of model organisms, outline of strategies in biochemical investigations employing whole animal studies, isolated organs, tissues, and cell cultures. Investigations with microorganisms and their mutants yeast, *Ceanorhabditis elegans*, *Arabidopsis thaliana* and *Drosophila melanogaster* as model specimen for biochemical investigations. Extractions; Preparation of organic and aqueous extracts for biochemical investigations, physicochemical properties of metabolites and drugs extracts from biological materials. Physicochemical properties of solvents, solubility and miscibility, ionic bonds, and salting out. Partition, ionization, buffering and their effect on extraction. Choice of solvent for solvent extraction, mixed solvents, solid phase extraction. **12 hrs**

Microscopic techniques

Principle of light microscope, Optical contrast, phase contrast, and dark field microscopy, resolution of microscopes, preparation of specimen for biochemical investigations.
Electron microscopy; Working principle and applications, specimens for electron microscopy, fixatives, immune-gold microscopy and its advantages. Metal shadowing, design and applications of Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), and cryo-electron microscopy. 3-D images, negative staining, single particle reconstruction, Fluorescence microscopy and Atomic force microscopy **7 hrs**

Centrifugation

Principle of centrifugation, the Svedberg equation, types of centrifuges and rotors. Density gradient centrifugation. Cesium chloride and sucrose density gradients; examples of separations, Subcellular fractionation. Design and working of analytical ultracentrifuges, sedimentation velocity and sedimentation equilibrium analyses.
Ultra-filtration; Principle, instrumentation and application. Dialysis, principle and uses of equilibrium dialysis. Precipitation; methods and applications.
Flow Cytometry; Principle and design of flow cytometer, cell sorting. Detection strategies in flow cytometry and parameters measured by flow cytometry. **7 hrs**

Biocalorimetry

Arrhenius equation, determination of energy of activation from Arrhenius plots. Main thermodynamic parameters; enthalpy, and entropy. Isothermal titration calorimetry, design of experiments, determination of change in heat capacity, eg-DNA duplex. Determination of specific heat from enthalpy. Differential scanning calorimetry; design of experiment, application of DSC, microcalorimetry. Determination of thermodynamic parameters by non-calorimetric data. **5 hrs**

Radioisotopic methods of analysis

Atomic stability and radiation, types of decay, rate of radioactive decay, half-life, units of radioactivity. Detection and measurement of radioactivity.

Design and applications of Geiger Muller Counter and types of scintillation counters. Disadvantages of scintillation counters, quenching, Chemiluminescence and phospholuminescence counting efficiency, channel ratio, sample preparation, scintillation cocktails, Cerenkov counting. Autoradiography; types of emulsions and films for exposure to isotopes, suitable isotopes, times of exposure and processing films, direct autoradiography, fluorography, intensifying screens, quantification.

Radio tracer techniques; Supply storage and purity of radiolabeled compounds, specific activity, radiolabeled nucleotides, metabolites. Pulse chase experiments. **10 hrs**

Introduction to Bioinformatics

Definition and overview, Nucleotide and protein databases, genome database, EST tag databases and SNP database. Tools for primary structure analysis; BLAST programme, FASTA, ClustalW, hydropathic plots, prediction of secondary structure and identification of protein families. Tertiary structure database; PDB, and MMDB. Programs for analysis and visualization of tertiary structure: RasMol/RasTop, protein explorer, Swiss-prot Pdb viewer, Homology modeling: modeling proteins from known homologous structures, CADD; Types of Docking and QSAR models. **10 hrs**

References

1. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011)
2. Basic Methods for the Biochemical Lab; Martin Holtzhauer, Springer, (2007).
3. Principles and Techniques of Biochemistry and Molecular Biology 7th Edn. Keith Wilson and John Walker, Cambridge University Press, (2010).
4. Principles of Gene Manipulations; 6th Edn. S.B. Primrose, R.M. Twyman, and R.W. Old Blackwell Science (2012).
5. Techniques in Molecular Biology, Walker and Gastra, Croom Helm, (1983)
6. Biochemistry LabFax, Ed. J.A.A. Chambers and D. Rickwood,, Blackwell Science, (1993),
7. Protein Purification Applications, S.L.V. Harris and Angal IRL Press, (1990)
8. Laboratory Techniques in Biochemistry and Molecular Biology, Work and Work Vol. I & II, North Holland, (1969).
9. Nucleic Acid Blotting; D C Darling, P M Bricknell; Garland Science; (1994)
10. Introduction to Proteomics; Daniel C. Liebler, Humana Press (2002),.
11. Introduction to Bioinformatics; T K Attwood & D J Parry-Smith, Pearson Education (2002).
12. Biophysical Tools for Biologists In Vivo Techniques; John Correia H. Detrich, III Elsevier (2008).

13. Recent Advances in Electron Microscopy- Part-A; B.V. Venkartarmaprasad, and Steve Ludtke, Academic Press (2010)

BCT – 203: Immunology

4 Units (52 hrs)

Overview of Immune system

Introduction, immunity- types- innate, acquired. Primary and Secondary lymphoid organs, lymphoid tissues. Immunoreactive cells- structure and functions-macrophages, granulocytes, NK cells, T and B lymphocytes – origin, development, differentiation, lymphocyte subpopulation in humans, Primary and secondary immune response. **6 hrs**

Antigens

Antigens and immunogenicity- terminologies and definition- antigen, immunogen, haptens, super antigen, tolerates, epitope, paratope. adjuvants- structure and properties . Features associated with antigenicity and immunogenicity, MHC antigens – types and importance-distribution and function. **3 hrs**

Antibodies

Immunoglobulin- structure, types, distribution, biological and chemical properties, Monoclonal and polyclonal antibodies- Methods of raising antibodies, Purification of polyclonal antibodies. Monoclonal antibodies; Principle of monoclonal generation and limiting dilution cloning, hybrid antibodies and purification of antibodies, poly reactive antibodies, abzymes. Theories of antibody formation; clonal selection and network, Genetics of antibody diversity, germline and somatic mutation theories. Immunoglobulin gene organization and their recombination, class switch of Ig genes. **7 hrs**

Complement system

Complement system – mode of activation- Classical, Alternate and Lectin pathways, biological functions and mechanism of complement system regulation. **4 hrs**

The Immune Response

Antigen recognition – TCR, BCR, MHC restriction, lymphocyte activation, clonal proliferation and differentiation. Antigen processing and presentation. Role of MHC. T cell and B cell interaction. Cytokines, monokines, lymphokines and their functions. Physiology of acquired immune response – various phases of HI, CMI – cell mediated cytotoxicity, DTH response. MHC and TCR gene organization and their recombination. **7 hrs**

Immuno assay methods

Antigen–antigen interaction: affinity and avidity. Determination of affinity and avidity constants. Principle, procedure and applications of Immuno precipitation, neutralization, agglutination, compliment fixation, immunodiffusion, immunofluorescence, FACS, RIA, ELISA and micro ELISA Techniques. Complement fixation assay, Cell and tissue staining

techniques, Immuno capture polymerase chain reaction (PCR), ChIP assay, Immuno affinity chromatography (IAC), Antibody-based biosensors. **6 hrs**

Clinical immunology

i)Immunodeficiencies

Primary Immunodeficiencies states in the human. Deficiencies of innate immune mechanisms- Phagocytic cell defects, Complement system deficiencies. Immunoglobulin deficiencies, Primary T-cell deficiency, Primary T-cell dysfunction, Severe combined immunodeficiency (SCID)- Mutation in the common cytokine receptor γ c chain and purine salvage pathway enzymes. Secondary immunodeficiency, Acquired immunodeficiency syndrome (AIDS)- Characteristics of HIV, infection and diagnosis. **3 hrs**

ii)Hypersensitivity

Type I: Anaphylactic hypersensitivity-causes and diagnosis of Type I hypersensitivity. Type II: Antibody-dependent cytotoxic Hypersensitivity-Type II reactions between members of the same species (allo-immune), Auto-immune type II hypersensitivity reactions, Anti-receptor autoimmune diseases, Type II drug reactions. Type III: Immune complex-mediated hypersensitivity- Inflammatory lesions due to locally formed complexes, Disease resulting from circulating complexes, Type IV: Cell-mediated (delayed-type) hypersensitivity-Tissue damage produced by type IV reactions. **4 hrs**

Tissue and Organ Transplantation

Immunologic Basis of Graft Rejection, Clinical Manifestations of Graft Rejection, Immunosuppressive Therapy, Immune Tolerance to Allografts, Clinical Transplantation. **4 hrs**

Cancer Immunotherapy

Oncogenes and Cancer Induction, Tumors of the Immune System, Tumor Antigens, Immune Response and Evasion. . **3 hrs**

Vaccine Development and Immunization

Vaccines- Active and Passive Immunization, Designing Vaccines for Active Immunization- Types of vaccines- Whole-Organism, Purified Macromolecules, Recombinant-Vector, DNA and RNA, multivalent Subunit, Toxoids, antisera, edible, plantibodies and recombinant antibodies. Common immunization programmes- BCG, small pox, DPT, polio, measles, Hepatitis-B, H1N1. Applications of immunologically relevant antigens and T cell subtypes in vaccine development. **5 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. Rohitt & 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. Immune System; M. C. Connel et al., Eds. (1981) Blackwell Science.
7. Immunology at a Glance: J.H.L. Playfare [ed.] Blackwell Science, (1987).
8. Immunology; Jan Klein [Ed.], Blackwell Science (1990).
9. Introduction to Immunology; Kim Bell [Ed.,] 3rd Edn. McMillan (1990).
10. NMS for Immunology; Hyde and Patnide [Eds.] John Wiley (1990).
11. Microbiology; Prescott, Harley and Klein, McGraw-Hill (2003).
12. Molecular Toxicology; Nick Plant, Garland Science (2003).
13. Understanding Immunology (Cell and Molecular Biology in Action); Peterwood, Pearson Education Ltd. (2006).
14. Introduction to Exotoxicology, En. D.W. Connell, Blackwell Scientific (2000)
15. Molecular Cell Biology Baltimore et al., Scientifica Americal Publication (1995).
16. Molecular Pharmacology, ed. T. Kenakin, Blackwell Science Inc (1997).
17. Toxicological Chemistry and biochemistry; Manahan, Stanley E. CRC Press LLC (2003).

BCT-204: Metabolism I

4 Units (52 hrs)

Unit 1: Carbohydrate metabolism

Introduction, glycolytic pathway and regulation. Fates of pyruvate, Feeders pathways, Rapoport-Leubering cycle –importance. Gluconeogenesis- pathway and regulation. The TCA cycle and its regulation. Alternate pathways: HMP pathway, Enter – Doudoroff, Glucuronate and Glyoxylate pathway, Cori's cycle, futile cycle and anaplerotic reactions. **10hrs**

Unit 2: Glycogen and starch metabolism

Degradation, synthesis and regulation, glycogen storage disorders. Pasteur effect, Warburg effect. Regulation of blood glucose level, hypo / hyperglycemia. Diabetes mellitus: introduction, biochemical and clinical changes associated with IDDM and NIDDM, control of hyperglycemia, diagnosis of Diabetes mellitus and GTT. Pentosuria, Hexose interconversion, fructose and lactose intolerance, Glucose-6-phosphate dehydrogenase deficiency, fructosuria, galactosemia. **10hrs**

Unit 3: Lipid metabolism

Oxidation of fatty acids: even and odd numbered, unsaturated and branched chain fatty acids. Catabolism of triacylglycerols and phospholipids. Glycerol metabolism Energetic of β-oxidation. Brief mention of alpha and omega oxidation. Metabolism of ketone bodies; their formation, oxidation and clinical significance. Fatty acid biosynthesis, fatty acid synthase, ACP structure and function. Biosynthesis of triacylglycerols, phospholipids and sphingolipids. Sphingolipidodystrophies. Metabolism of prostaglandins. Cholesterol biosynthesis, catabolism and regulation. Transport of cholesterol -LDL receptor pathway. Reverse Cholesterol Transport. Arachidonic acid metabolism-Leukotrienes **11 hrs**

Unit 4: Bioenergetics and Biological oxidation

Basic concepts of metabolic energy capture and transfer. Biochemical energetic group transfer reactions of ATP, phosphate group transfer potential of ATP and other high energy phosphate donors. Stages in extraction of energy from fuel molecules.
Biological redox couplers, participation in oxidative metabolism. Free energy changes in electron transfer reactions. Mitochondrial electron transfer system Chemical nature, topology and thermodynamic design of electron carriers. Sequence of electron carriers Isolation of mitochondrial complexes, reconstitution experiments and study of specific inhibitors of Electron Transport Chain. Reverse Electron Transport chain. **6hrs**

Unit 5: Oxidative phosphorylation

Mechanism of proton pumping. Proton motive force and the Mitchell hypothesis. FoF1-ATPase-structure and mechanism, O18 exchange. Coupling of electron transfer to ATP synthesis. Uncouplers, inhibitors and ionophores, partial reactions of OP, P/O ratios and their use in localization of sites of ATP synthesis along the chain.
Mechanism of oxidative phosphorylation . Boyer's Binding change mechanism of Rotational catalysis, mitochondrial specific transport systems and energy charge- Glycero-phosphate and Malate-Aspartate shuttle system. Microsomal electron transport. Proton motive force in Halobacteria, ATP synthesis in bacteria. H + pumping by bacteriorhodopsin Photosynthetic electron transport. Structure and function of chloroplast ATP- synthase. **7 hrs**

Unit 6: Photosynthesis

Introduction, chloroplast/thylakoid structure. Ultra structure and organization and lipid composition of thylakoid membranes. photosynthetic apparatus - PS I and PS II.Hill reaction, light reaction, cyclic- and non-cyclic photophosphorylation. Quantum yield of Photosynthesis. Dark reactions, CO2 fixation: C3 and C4-pathways. Crassulacean acid metabolism. Photorespiration. Bacterial photosynthesis. **8 hrs**

References

1. Biochemistry; Voet , D. and Voet, J.G. [Eds.] (1999) 3 Ed. Jhon Wiley and sons.
2. Biochemistry; David Rawn, J. (1989) Neil Patterson Publishers.
3. Principles of Biochemistry; Smith et al., [Ed.] (1986) McGarw Hill.
4. Bioenergetics; A Practical Approach, G.C. Brown and C.E. Cooper (1995) IRL- Oxford University Press.
5. Photosynthesis, D.O. Hall and K. K. Rao, (1999), 6th Edn. Cambridge University Press.
6. Hawk's Physiological Chemistry, Oser (1976) 14th Edn Tata-McGraHill.
7. Advances in Carbohydrate Chemistry and Biochemistry; Horton, Elseveir (1994).
8. Biochemistry of Foods, EskinElseveir (2012).
9. Text Book of Biochemistry with Clinical correlations; 6th Edn. Thomas M. Devlin, Wiley-Liss (2012).
10. Lehninger- Principles of Biochemistry; D. L. Nelson and M.M. Cox 6th Edn. Macmillan Publications (2012).
11. Biochemistry and Molecular Biology; 5th Edn. D. Papachristodoulou, A. Snape, W.H. Elliott, and D. C. Elliott, Oxford University Press (2014).
12. Biochemistry; David Rawn, Panima Publishers (2012).

BCS–205: Microbiology

3 Units (39 Hrs)

Microbial classification

Taxonomy- definition, phonetic and phylogenetic classification. Binomial nomenclature, international code of nomenclature of prokaryotes. Taxon, species, strain.
Molecular methods in taxonomy- nucleic acid base composition, DNA homology, DNA-RNA homology, rRNA sequencing, DNA fingerprinting, Flow cytometry.
Chemotaxonomy: Cell wall components, lipid composition, isoprenoid- quinones, cytochrome composition, fatty acid profiles; Numerical taxonomy.
Classification of bacteria according to Bergey's Manual of systematic Bacteriology, Dichotomous keys, Cladograms, dendrograms, universal phylogenetic tree. **6 hrs**

Eukaryotic micro organisms

Distribution and occurrence, morphology, structure, mode of reproduction, economic importance of protozoans, algae and fungi. Cultivation of protozoans, algae and fungi. **6 hrs**

Morphology and ultrastructure of bacteria

Different cell morphology, flagella, pili, capsule, cellwall, cell membrane, cytoplasm. Inclusion bodies, nucleoid, plasmids, reserved food materials (metachromatic granules, polysaccharide granules, polyhydroxy butyrate granules, cyanophycean granules and sulphur globules), endospores and exospores.

General properties of coliform, spore formers, lactic acid bacteria, actinomycetes, rickettsiae, spirochetes, cyanobacteria and Archaea. Gram, Acidfast & flagellar staining. **7 hrs**

Viruses, Viroids and Prions (Acellular entities)

General characters, Structure, nomenclature and classification, Isolation, cultivation and Identification of Viruses (Growing in Bacteria, animal inoculation, embryonated eggs, Cell Cultures). Inactivation of viruses by physical and chemical agents. Viroids and Prions-General properties and diseases. **5 hrs**

Nutrition, Cultivation and control

Micro and macronutrients, Nutritional types of bacteria. Culture media**,** classification of media (Simple, complex and special media with example). Growth- Growth curve, factors affecting growth. Batch and continuous cultivation. Microbial growth control- Physical methods (Heat, Pasteurization, Filtration, Radiation, Desiccation, Low Temperature, High Pressure, Osmotic Pressure) and Chemical Methods (Phenols, Halogens, Alcohols, quaternary ammonium compounds). **5 hrs**

Microbiological methods

Enumeration methods-DMC, SPC, MPN, MFT and turbidometric enumeration. Evaluation of antiseptics and disinfectants. Antibiotic assay. Determination of MIC- disc and well diffusion method. **3 hrs**

Microbial Applications

Fermentation technology – fermentation, basic steps in industrial fermentation process (upstream and downstream), design of typical fermenter, production of penicillin and beer.

Environmental microbiology – production of biogas, bioleaching. Bioremediation- definition, bioremediation of heavy metals and pesticides.
Dairy microbiology – Production of yoghurt. Probiotics and prebiotics.

7 hrs

REFERENCES

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4th edition. John and Sons, Inc.
2. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.
3. Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition.Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition.McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.
8. Vashishta BR and Sinha AK. (2008). Fungi. S. Chand and Company Ltd.
9. Vashishta BR. (2005). Algae. 3rd edition. S. Chand and Company Limited, New Delhi.
10. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology.7th edition. McGraw Hill Higher Education.
11. Dimmock NJ, and Primrose SB. (1994). Introduction to Modern Virology. 4th edition. Blackwell Science Ltd.
12. Wagner EK, Hewlett MJ. (2004). Basic Virology. 2nd edition. Blackwell Publishing.
13. Mathews. (2004). Plant Virology. Hull R. Academic Press, New York.
14. Nayudu MV. (2008). Plant Viruses. Tata McGraw Hill, India.
15. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ).University Press Publication.
16. E.L. Jordan and P.S. Verma. (2009), Invertebrate Zoology, S. Chand and company

BCP -206: Immunochemical Techniques and Bioinformatics (4 Credits)

1. Culturing and Isolation of Bacteria and Grams staining, endospore staining
2. Culturing and Isolation of fungi and Fungal staining.
3. Animal cell culture and Trypan blue assay
4. Demonstration of Ag-Ab interaction: Radial immuno-diffusion and ODD.
5. Demonstration of direct agglutination reaction using human blood group antigens.
6. Demonstration of indirect agglutination reaction-latex agglutination.
7. Antibody titration – ELISA; Direct, Indirect, sandwich, and micro ELISA.
8. Purification of antibodies; conventional (isolation of IgY from Egg yolk).
9. Rocket electrophoresis.
10. Pair wise alignment: BLAST and FASTA of protein
11. Multiple alignment and Phylogenetic analysis of protein
12. Homology modeling using Swiss PDB and Rasmol-Insulin/Cox 2
13. Docking using Autodoc Pyrex

BCP – 207: Enzymology (4 Credits)

1. Determination of total activity of pea esterase.
2. Determination of Km and Vmax of pea esterase.
3. Determination of optimum pH of pea esterase.
4. Determination of pH stability of pea esterase.
5. Determination of optimum temperature and activation energy of pea esterase.
6. Determination of temperature stability of pea esterase.
7. Determination of type of inhibition (reversible or irreversible) of pea esterase.
8. Determination of IC 50 of pea esterase using organophosphate inhibitor.
9. Determination of total activity of salivary α-amylase /β-amylase (Diastase or germinated ragi).
10. Determination of Km and Vmax of α -amylase / β -amylase.
11. Determination of Km and Vmax of alkaline phosphatase (potato).
12. Determination of type of inhibition (reversible or irreversible) of alkaline phosphatase.
13. Determination of IC50 of alkaline phosphatase.
14. Determination of inhibitor constant, Ki of alkaline phosphatase.
15. Determination of optimum temperature and activation energy of urease (Jackbean meal)

Members present:

BOS panel (External)	**BOS panel (Internal members)**
1. Dr.Chandrakant S Karigar (University nominee)	**1. Dr. Kushalatha M (BOS Chairman)**
2. Dr. G.J. Sathisha (Subject expert)	**2. Dr. Kamala A**
3. Dr. Vasantha Kumar Bhaskara (Subject expert)	**3. Ms. Vani K. (Ph.D)**
4. Dr. Manjula J (Industry expert)	**4. Ms. Usha T (Ph. D)**
5. Ms. Chitra Gopinath (Alumnus)	**5. Dr. Pradeep Kaushik**
	6. Dr. Umesh HR
	6. Ms. Jayashree N. S

Sd.
Chairperson, Dept. of Biochemistry
mLAC, Bangalore


CHAIRPERSON
Board of Studies (BOS)
Department of Biochemistry (PG)
Maharani Lakshmi Ammanni College
for Women, Autonomous
Malleswaram, Bangalore - 560012

Maharani Lakshmi Ammanni College for Women Autonomous
Affiliated to Bengaluru City University
Re-accredited by NAAC with "A" grade, Recognised by UGC
under Section 2(f) and 12(b) of the UGC Act 1956
Conferred the Status of 'College with Potential for Excellence' by UGC
mLAC
Excellence in Education
Since 1972
1972-2022

Syllabus for
M. Sc. Biochemistry
Choice based credit system **(CBCS)**

III and IV Semesters
(With effect from 2022 onwards)

Department of Biochemistry,
mLAC, Autonomous
Bangalore -560 012

May 2022

Name of the Course: **M. Sc. Biochemistry**

Duration of the course: **Two years**

Eligibility: Candidate must have secured 40% in aggregate and studied Chemistry (or) Biochemistry as one of the cognate subjects securing 50% marks at B.Sc. level, and studied Biology at PUC (or) 10 + 2 level.

Intake: 20

Admission: As per the prevailing University regulations.

SCHEME OF STUDY AND EXAMINATION

III& IV SEMESTER M. Sc. BIOCHEMISTRY COURSE (Autonomous)

Third Semester					
Paper Code	**Title of the paper**	**Contact**	**Exam.**	**Marks**	**Credits**

		hours	hours	IA	Exam	Total	
BCT – 301	**Molecular Biology**	4	3	30	70	100	4
BCT – 302	**Analytical Biochemistry II**	4	3	30	70	100	4
BCT – 303	**Metabolism II**	4	3	30	70	100	4
OET*	**Open elective***	4	3	30	70	100	4
BCP – 305	**Bioanalytical Techniques**	8	4*	30	70	100	4
BCP – 306	**Molecular Biology**	8	4*	30	70	100	4
	Total					600	24

Fourth Semester							
Paper Code	**Title of the paper**	**Contact hours**	**Exam. hours**	**Marks**			**Credits**
				IA	**Exam**	**Total**	
BCT – 401	**Gene Regulation**	4	3	30	70	100	4
BCT – 402	**Molecular Genetics**	4	3	30	70	100	4
BCT – 403	**Genetic engineering**	4	3	30	70	100	4
BCT – 404	**Molecular Signaling**	4	3	30	70	100	4
BCP – 405	**Genetic Engineering and Protein Chemistry**	8	4*	30	70	100	4
BCP – 406	**Project**	8	Report	30	70	100	4
	Total					600	24

Scheme for Continuous Evaluation

Theory Paper (each)

Attendance:	05 Marks
Tests*:	15 Marks
Assignment:	05 Marks
Seminar/Presentation:	05 Marks
Total:	**30 Marks**

*Two tests will be conducted and average of marks from two tests shall be computed for continuous evaluation

Practical (each)

Attendance:	05 Marks
Practical Tests*:	20 Marks
Record:	05 Marks
Total:	**30 Marks**

*Two tests shall be conducted and average of marks from two tests shall be computed for continuous assessment.

Question paper pattern for End semester theory Examination

Time: 3hrs **Max. Marks: 70**

Instruction to the students: 1) The question paper has three parts (Part A,B & C)

2) Answer all the parts

3) Draw diagrams and write chemical equations **wherever** necessary

Part A, Question number I, shall have 12 sub questions 1 to l2 of two marks each, and the student has to answer any **Ten** of them. **(2X10=20)**

Part B, Question No. II, Shall have 7 questions; student has to answer any five question each carries 4marks **(5X4=20)**

Part C, Question No. III, Shall have 7 questions; student has to answer any five question each carries 6marks. **(5X6=30)**

Question paper pattern for end semester Practical Examination

Time: 4h **Max. Marks: 70**

1. Give the principle and procedure for …. 10

2. Perform any one of the experiments listed in the syllabus for the semester. 35
3. Viva-Voce. 15
4. Practical record. 10

Project Evaluation **Max. Marks: 100**

Internals (Max.Marks:30)	**Report (Max.Marks:50)**	**Viva-Voce (Max.Marks:20)**
To be provided by the Supervisor through the Chairman/Principal	To be evaluated for overall objective and quality of work presented in the report.	Performance of the candidate

III Semester

BCT 301 MOLECULAR BIOLOGY

4 UNITS (52 hrs)

Course outcome

- This paper expects the students to gain an overall understanding of the basic mechanisms involved in cell with respect to the central dogma of molecular biology.
- They also understand the relationship between genes and proteins, experimental evidence of DNA and RNA discovery, mechanisms of prokaryotic and eukaryotic replication, the molecular components DNA repair system and their significance.
- Students get acquainted with the concept of transcriptome, prokaryotic RNA polymerase; post transcriptional modifications, Genetic code, experimental results leading to deciphering genetic code, the structure of prokaryotic and eukaryotic components and their assembly.

UNIT 1: INTRODUCTION

Central dogma of molecular biology Relationship between genes and proteins., Nature of genetic material, experiments confirming DNA and RNA as genetic material. Variation in size and shape of genomes; ultracentrifugation and electron microscopic methods to study the shape and size of genomes. Relationship between size of genome and genetic capacity; C-value paradox. Organelle genomes, Genome sequence and gene numbers. **04 Hours**

UNIT 2: PROKARYOTIC DNA REPLICATION

Replicon, single and multicopy replicons, linear and circular replicons, unidirectional, bidirectional and rolling circle replication, experimental methods, mapping origin of replication, semi-conservative and semi-discontinuous replication; experimental demonstrations. Priming

DNA synthesis in bacteria; experimental evidence, components of primosome. Initiation at origin (oriC) of E. Coli. Creation of replication forks. Regulation of initiation at origins, sequestration of origins after replication Topological problems in DNA replication; Role of topoisomerases, helicase, gyrase, single strand DNA binding proteins and ligases. Mechanism and classification of topoisomerases, assay of topoisomerases. Assay of helicase.

*Enzymology of DNA replication***:** DNA polymerases, chemistry of nucleotide polymerization and in vitro assay, Hand-palm structure of DNA polymerases. Use of conditional lethal mutants and in-vitro complementation methods for identification of replicative polymerase. Properties and functions of DNA polymerase I, Korenberg enzyme. Subunit composition of polymerase –III holoenzyme, identification of functions of individual subunits by complementation and mutational studies mechanism of replication of E. coli DNA-trombone model, termination of replication. Processivity and fidelity of replication. Bacterial replication and its connection to cell cycle. Replication of phage DNA φX174 in *E.Coli.* **09 Hours**

UNIT 3: EUKARYOTIC DNA REPLICATION

Replicative and repair enzymes of eukaryotes. Initiation, elongation by eukaryotic DNA polymerases. SV-40 replication using eukaryotic replicative machinery. Isolation of ARS of yeast, ORC, Licensing factors and control of eukaryotic DNA replication, role of MCM proteins. Replication of organelle genomes, maintenance of ends of linear DNAs; telomeric DNA and telomerase. Regulation of eukaryotic DNA replication and inhibitors of DNA replication.

04 Hours

UNIT 4: DNA REPAIR

Experimental demonstration of repair in prokaryotes, damaging agents and damage recognition, direct repair, Mis-match repair assay for mismatch repair, Base excision repair (BER), Nucleotide excision repair (NER) systems; components and mechanism of repair, error prone repair, SOS and Rec-A. Eukaryotic BER and NER, controlling direction of mismatch repair, DNA damage in chromatin. Human diseases related to DNA repair.

05 Hours

UNIT 5: TRANSCRIPTION IN PROKARYOTES AND EUKARYOTES

The transcriptome, prokaryotic RNA polymerase; molecular composition, and mechanism of transcription. Initiation of prokaryotic transcription; Structure of bacterial promoters. Effect of sigma factor on binding of RNA pol. to promoters. Structure and function of sigma factor, reuse of sigma factor (sigma cycle). Sigma movement relative to DNA: FRET assay. DNA melting at promoters, promoter clearance. Role of α-subunit in upstream element recognition. Foot-printing

of upstream elements with α-subunit. Elongation: Role of β-subunit in phosphodiester bond formation. Structure of elongation complex and core polymerase. Termination of transcription: Rho- dependent and independent, termination, RNA product under Rho dependent termination.*Transcription in eukaryotes***:** Separation of nuclear RNA polymerases- rat liver RNA pol. Roles of the RNA polymerases. Sensitivity to α-amanitin. Subunits of RNA pol-II (yeast polII). Heterogeneity of Rpb1 subunit. Formation and maintenance of transcription bubble. Eukaryotic promoters: Class-II core promoter, modular organization, SV40 early promoter. Linker-scanning mutagenesis, TATA Box, downstream promoter elements, proximal promoter elements, TATA-less promoters and initiators. Class-I and Class-III promoters, Enhancers and silencers. Class-II pre-initiation complex, foot-printing DAB Structure and function of TFIID, TBP and associated factors (TAFs). Phosphorylation of CTD of RNA pol-II, Mediator complex and RNA pol-II. Elongation factors: Effect of TFIIS, reversal of transcription arrest, proof reading of transcripts. Composition and working of transcription units at class-I and class-III promoters. **13 Hours**

UNIT 6: RNA PROCESSING

Split genes, RNA splicing: R-looping experiments, splicing signals, effect of splicing on gene expression. Splicing of nuclear mRNA precursors. Branched intermediate, mechanism of RNase T_1 and T_2, direct evidence for a branched nucleotide. Signal at branch. Spliceosomes: snRNPs, U1snRNP, detection of spliced product by RNase protection assay. U6snRNP, U2snRNP and U4snRNP. Spliceosome assembly and function. Alternative splicing, exon-intron definition. Commitment of precursor RNA to splicing, role of sr protein. Yeast two hybrid assay. Role of RNA pol-II in splicing, control of splicing. Self splicingRNase. Group-I introns, demonstration of exon ligation, Group-II introns. Post transcriptional modification of mRNA: Structure of cap, purification of caps, capping substrate, functions of cap. Polyadenylation: Function of poly A, mechanism and signals for polyadenylation. Cleavage and Polyadenylation for mRNA elongation of poly-A, poly-A binding protein (PABP), turnover of poly-A. Coordination of mRNA processing with Coupling termination and mRNA 3' end processing. **05 Hours**

UNIT 7: GENETIC CODE

Genetic code; breaking the code, experimental results leading to deciphering genetic code, coding properties of mRNA, Co-linearity of genes and proteins, decoding properties of tRNA, triplet binding assay, use of synthetic oligo nucleotides (works of Khorana and Neirenberg), base pairing between codon and anti-codon, Wobble hypothesis Properties of genetic code, deviation from universal genetic code. Contextual reading. **03Hours**

UNIT 8: RIBOSOMES AND TRANSLATION

Prokaryotic ribosomes; molecular components, in vivo assembly, dissociation of subunits, and polysomes. Eukaryotic components and their assembly, organelle ribosomes.

*Translation:*Initiation of protein synthesis in prokaryotes, Shine-Dalgarno sequence, formation of initiation complexes; effect of GTP hydrolysis by IF2. exchange of ribosomal subunits. Eukaryotic translation initiation-scanning model, eukaryotic initiation factors, role of eIF4E, F, and G. Formation of stable 48S initiation complex, role of eIF1 and eIF1A, toeprint assay, direction of polypeptide synthesis and mRNA translation. Control of translation in bacteria and eukaryotes. Elongation ; Amino acyl-tRNA synthetases, formation of ternary complex among amino-acyl tRNA, EF-T, and GTP, three site model of ribosome, peptide bond formation, ,Termination of translation :stop codon suppression-suppressortRNA, release factors, aberrant termination, non-stop mRNAs, , no-go-decay of mRNA. Inhibitors of prokaryotic and eukaryotic translation. Mechanism of translational control (transferrin/ferritin).Post-translational modifications of proteins. **09Hours**

References:

1. Biochemistry and Molecular Biology of Plant; Buchanan, Gruissum and Jones, (2000),ASPP, USA.
2. Biochemistry; David Rawn, Panima Publishers (2012).
3. The Bacteriophages; Richard Calendar, 2nd Edition, Oxford University Press (2005).
4. Basic Virology; Wagner and Hewlett; Blackwell Science, (2004)
5. LEWINS Gene XI; J.E. Krebs, E.S. Goldstein, and S.T. Kilpatrick, Jones and Barttlett Publishers (2012).
6. Molecular Biology of the Cell, Alberts et al., Garland Publications, (2012).
7. Molecular Biology, David Freifelder, Narosa Publishers, (1997).
8. Molecular Biology Robert F. Weaver, McGraw Hill (2012).
9. Microbial Genetics; Maloy et al., Jones and Bartlett Publishers, (1994).
10. Modern Microbial Genetics; Uldies N. Streips and Ronals E. Yasbin, Wiley Leis Inc. New York, (2002).
11. Molecular biology and Biotechnology; 4th Edn., J.M. Walker and R. Rapley, RSC (2000).
12. Molecular Biology of Gene; Watson, J.D. et al., 5th Edn. Pearson Education; (2004).
13. Principles of Virology; S.J. Flint et al., ASM Press (2000).
14. Chromatin structure and Gene Expression; 2nd Edn. Sarah Elgin, Jerry Workman, OxfordUniversity Press (2000)
15. Molecular Cell Biology; Harvey Lodish 5th Edn. (2010)
16. Biochemistry 5th Edn. Jeremy M. Berg, John L. Tymoczko, LubertStryer (2011).
17. Viruses: Biology, Applications, and Control; David Harper, Garland Science (2011).

BCT 302: ANALYTICAL BIOCHEMISTRY II

4 UNITS (52 hrs)

Course outcome

- This course is to familiarize students with the basic concepts and applications of modern techniques used in Biochemistry, Biophysics, Cell and Molecular Biology.
- The students will be able to understand the principle and working of different chromatography techniques.
- The students will be able to understand the principle and working of different spectroscopic techniques.
- The students will be able to understand the principle and working of different Electrophoretic and molecular biology techniques.
- The students will be able to understand mass spectrometer working, protein sample preparation, molecular weight determination, and base peak from a mass spectrum.

UNIT 1: CHROMATOGRAPHY

Introduction, partition coefficient phase systems, liquid and solid phases, principle procedure and application of paper chromatography, parameters employed in column chromatography, retention, resolution, physical basis of peak broadening , plate height equation, capacity factors, peak symmetry, standard systems of chromatography and its components, stationary phase, elution.

Types of chromatography: Ion exchange, major ion exchange matrices, elution in ion exchange chromatography. Examples of cation and anion exchangers, chromatofocusing.

Gel filtration: matrix used fractionation range and matrices, determination of native mass of proteinbygelfiltration. Reverse phase principle and procedure.

Hydrophobic interactions and affinity chromatography: Affinity ligands, immobilization of ligands.Activation of matrices, coupling affinity ligands (example–GSH). Metal affinity chromatography, His tag, open column chromatography, hydroxyl apatite chromatography.

Thin layer chromatography: Introduction; phases used in TLC preparative TLC, metabolic profiling, solvent systems for TLC. Detection of compounds on TLC plates. **09 Hours**

UNIT 2: GAS CHROMATOGRAPHY

Principle and design of instrument. Factors affecting GC, stationary phase, mobile phase, column length, diameter, film thickness, flow rate temperature, sample introduction. Detectors: flame ionization, thermal ionization, electron capture, mass selective detection. GLC; principle and application. **06 Hours**

UNIT 3: HPLC

Instrumentation, column, pumps, plumbing, injectors, mobile phases in HPLC, two dimensional HPLC, factors affecting resolution in HPLC chromatography, flow rate and linear velocity. Separate modes: normal and reverse, gradient reverse phase, ion suppression and ion pairing. Chiral-HPLC, chiral columns. Detectors: types, UV, visible fluorescence, electrochemical detectors. Fast protein liquid chromatography (FPLC). **05 Hours**

UNIT 4: ELECTROPHORESIS

Historical developments, principle, non-denaturing PAGE, activity staining for enzymes, zymogram, denaturing electrophoresis (PAGE), SDS-PAGE, 2D, chemical cross linking of proteins urea electrophoresis, pulse field electrophoresis.

Immuno-electrophoresis:Dot blotting and immune-diffusion tests with antibodies, zone electrophoresis/immune-electrophoresis. Rocket electrophoresis, counter immune-electrophoresis, Agarose gel electrophoresis of nucleic acids, physical basis, equipment and applications.

Electroblotting: Western, Southern, Northern blot analysis **09 Hours**

UNIT 5: SPECTROSCOPIC TECHNIQUES

Wave particle duality of light, electromagnetic spectrum, transition in spectroscopy. Principle, design and application of UV-Vis spectrophotometry.Principle, design and application of fluorescence spectroscopy.

Spectroscopy techniques using plane polarized light, circular dichroism (CD), equipment for CD measurement, CD of biomolecules(proteins) and LD (linear dichroism) of biomolecules.

IR spectroscopy:Physical basis of IR spectroscopy. Instrumentation, use of IR in structure determination, Fourier transfer,

NMR:Principle, effect of atomic, identity on NMR, chemical shift, spin coupling NMR, measurement of NMR spectra, biochemical application of NMR.

ESR:Principle, measurement of ESR spectra uses of ESR in chemistry. **12 Hours**

UNIT 6: PROTEOMICS

Introduction to proteomics, Steps involve in proteome analysis; Sample preparation,In-gel digestion. Fundamentals of Mass spectroscopy: Principle, Types of Inlets, ionization modes, Mass analyzers, fragmentation modes (CID, HCD and ETD),intact protein analysis, protease digestion, peptide mass fingerprinting, tandem mass spectrometry, introduction to Data Independent Analysis (DIA),Protein sequence and spectral databases/ libraries. Quantitative proteomics- Differential proteomics, post-translational modifications, Targeted proteomics- Parallel reaction monitoring, Multiple reaction monitoring.**06 Hours**

UNIT 7: METABOLOMICS

Overview, basic sample preparation strategies- extraction, derivatization. Workflow for lipidomics; modes of data acquisition, data repositories. Targeted Versus Untargeted metabolomics; development of targeted assays for small molecules **05 Hours**

References:

1. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011)
2. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8 thEdn. Andreas Hoffman and Samuel Clockie, Ed., Cambridge University Press, (2018).
3. Biochemistry and Molecular Biology; 5th Edn. D. Papachristodoulou, A. Snape, W.H. Elliott, and D. C. Elliott, Oxford University Press (2014)
4. Discovering Genomics, Proteomics and Bioinformatics, Campbell A M &Heyer L J, 2 ndEdn. Benjamin Cummings, (2007).
5. Principle and Practice of Bioanalysis; Richard F. Venn (Ed.) Taylor and Francis (2000).
6. Hydrophobic interaction Chromatography, Principles and Methods, Stuart E. Builder, Amarsham-Pharmacea Biotech (1993).
7. Biochemical, Physiological, and Molecular Aspects of Human Nutrition, StipanukElseveir (2012).
8. Protein Bioinformatics; M. Michael Gromiha, Academic Press (1983).
9. The Physical Basis of Biochemistry: The Foundations of Molecular Biophysics, 2 ndedn. R. R. Bergethon, Springer, NY (2010).
10. Isoelectric Focusing; Theory, Methodology and Applications; P.G. Righetti , Elsevier (2013).
11. Fluorescence Microscopy; AndaCarnea and P. Michael Conn; Academic Press (2014).
12. Fluorescence Spectroscopy; Ludwig Brand and Michael Johnson, Academic Press (2008).
13. Metabolome Analysis: An Introduction, S.G. Villas-Boas. Wiley-Blackwell, USA. (2007)
14. Concepts in Plant Metabolomics, B. J. Nikolau. Wurtele, Eve Syrkin, Springer, USA (2007).

15. The Handbook of Metabonomics and Metabolomics, J. Lindon, J. Nicholson, E. Holmes. Elsevier B.V., Netherlands (2006)

BCT 303 – METABOLISM II

4 UNITS (52 hrs)

Course out come

- Understand and integrate the knowledge of nitrogen cycle and enzymes involved in it.
- The course will enable the students to have full knowledge of the pathway of amino acid and protein metabolism and gain competency in distinguishing the disease states associated with inborn errors of metabolism.
- The students will be able to integrate amino acid synthesis with specific precursors from glycolysis, citric acid cycle and the pentose phosphate pathway.
- Understand nucleotide and heme metabolism and their clinical manifestation.

UNIT 1: NITROGEN CYCLE

Introduction, biological and non-biological nitrogen fixation, nitrogenase complex, leghemoglobin nif genes and their regulation , uptake of nitrite and nitrates in plants, regulation of nitrate and nitrite reductase , Assimilation of ammonia, formation of amino acid amides by glutamine synthetase and its regulation. Nitrogen homeostasis. **06 Hours**

UNIT 2: 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). Urea cycle– regulation and metabolic disorders. Biosynthesis of creatine and creatine phosphate, polyamines– putrescine, spermidine and spermine, glutathione (γ-glutamyl cycle), physiologically active amines (γ–amino butyric acid, serotonin, α – histamine and catecholamines – dopamine, epinephrine and epinephrine). **09Hours**

UNIT 3: DEGRADATION OF THE INDIVIDUAL AMINO ACIDS

Pathways in animal, plant and microbial systems; Amino acids forming from pyruvate (alanine, glycine, threonine, serine, cystine and cysteine), oxaloacetate (aspartic acid and asparagine), α-ketoglutarate (glutamic acid, glutamine, arginine, histidine and proline), succinyl CoA (valine, isoleucine and methionine), acetoacetate and/or acetyl CoA (leucine and lysine), pyruvate, formaldehyde, acetoacetate and/or acetyl CoA (tryptophan), and fumarate, acetoacetate and/or acetyl CoA (phenylalanine and tyrosine). Inherited disorders associated with glycine, aromatic, branched chain, basic and sulfur containing amino acid metabolism. **12 Hours**

UNIT 4:BIOSYNTHESIS OF INDIVIDUAL AMINO ACIDS

Pathways in animal, plant and microbial systems– biosynthesis of non – essential amino acids from pyruvate (alanine), intermediates of glycolysis (serine) and TCA cycle (aspartic acid, asparagine, glutamic acid and glutamine), essential amino acid (tyrosine), non – essential amino acid (glycine, proline and arginine), and essential & non – essential amino acid (cysteine). Biosynthesis of essential amino acids from aspartate family of amino acids (threonine, lysine and methionine), pyruvate family of amino acids (valine and leucine), pyruvate and α−ketobutyrate family of amino acid (isoleucine), aromatic family of amino acids (phenylalanine, tyrosine and tryptophan) and histidine. Regulation of amino acid biosynthesis by sequential & concerted feedback inhibition.

12 Hours

UNIT 5: NUCLEOTIDE METABOLISM

De novo biosynthesis of purine and pyrimidine nucleotides and their inter conversion, regulation of biosynthesis.Other pathways of purine nucleotide formation. Role of Thymidylate synthase. Biosynthesis of deoxyribonucleotides and coenzymes nucleotides. Chemical inhibition of the biosynthesis of nucleic acid precursors. Degradation of purine and pyrimidines, and disorders associated with their metabolism; gout, Lesch-Nyhan syndrome, Oroticaciduria and Xanthinuria.

08 Hours

UNIT 6: HEME METABOLISM

Biosynthesis and degradation of porphyrin and their regulation, porphyrias, jaundice and Hemoglobinopathies. **05 Hours**

References:

1. Biochemistry- R. Garret, Charles M Grisham, Belmont (2013)
2. Biochemistry; Geoffrey Zubey, (1998), WCB Publishers.
3. Biochemistry; David Rawn, Panima Publishers, (1989).

4. Text Book of Biochemistry with Clinical correlations; 6th Edn. Thomas M. Devlin (2012), Wiley-Liss.
5. Lehninger- Principles of Biochemistry; D. L. Nelson and M.M. Cox 6th Edn. Macmillan Publications (2012).
6. Principles of Biochemistry; Smith et al., [Ed.] (1986) McGarw Hill.
7. Bioenergetics; A Practical Approach, G.C. Brown and C.E. Cooper (1995) IRL- Oxford University Press.
8. Biochemistry Ed. Donald Voet& Judith G. Voet, John Wiley & Sons, Inc. (2010).
9. Bioenergetics; David Nicholls and Stuart Ferguson, Elsevier (2013).

BCP-305: BIOANALYTICAL TECHNIQUES

(4 Credits)

Course outcome

- Students would develop separation and analytical skills with respect to different types of extraction techniques, types of chromatography, separation of biomolecules by paper chromatography and thin layer chromatography, visualization of the separated analytes and calculation of Rf values. They also learn the techniques of native PAGE and SDS PAGE involved in separation and analysis of proteins and nucleic acids. The units of this course are crucial for implementation of research ideas at molecular level.
- This course gives practical exposure to extraction of natural products, polyphenols and cell free homogenate of microbial/animal/plants.
- Overall, this course significantly enhances the employability of the candidates in Biotechnological, Pharmaceutical Industries and Analytical Laboratories and research institutes.

1. Ascending descending and circular paper chromatography of amino acids / carbohydrates
2. Two-dimensional chromatography of amino acids / carbohydrates.
3. Thin layer chromatography of carbohydrates / amino acids.
4. Gelpermeation chromatography of pigments/proteins.
5. Ion exchange chromatography of nucleic acids / proteins.
6. Separation of proteins by non-denaturing PAGE.
7. Determination of molecular weight of Proteins by SDS–PAGE
8. Separation of isoenzymes by isoelectric focusing

9. Extraction of natural products by Soxhlet method/ultrasound assisted/microwave assisted/ enzyme assisted/Decoction/heat reflux extraction method
10. Extraction and estimation of polyphenols by FC/Prussian-Blue methods
11. Extraction of cell free homogenate of plant/animal tissue/microbes

BCP – 306: MOLECULAR BIOLOGY

(4 credits)

Course outcome

- Studetns are expected to learn the skills involved in isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of genomic DNA, plasmid DNA, mRNA and RNA from different source such as bacteria (E. *coli*)/ plant/ animal sources.
- The course also enables the students to acquire hands on skill in molecular techniques such as restriction digestion, ligation of DNA, melting temperature determination, RAPD, RT-PCR, Phage titration and Southern blotting.

1. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of genomic DNA from bacteria (E. *coli*).
2. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of genomic DNA from plant by CTAB method.
3. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of plasmid DNA from animal source. (Not by TCA method)
4. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of total RNA from bacteria, mRNA from plant and microbial sources.
5. Restriction digestion and ligation of DNA.
6. Spectroscopic determination of melting temperature(Tm) of calf thymus DNA.
7. Amplification of desirable gene by Polymerase chain reaction.
8. Rapid amplification of polymorphic DNA.
9. Reverse transcriptase- Polymerase chain reaction RT-PCR
10. Southern blotting
11. Phage Titration.

IV Semester

BCT 401 GENE REGULATION

4 UNITS (52 hrs)

Course outcome

- The student on completion of this unit will be able to
- Describe the basic features of the structure of RNA polymerase
- Get acquainted to the principles of gene expression in both prokaryotic and eukaryotic systems.
- The students will gain an in-depth look at how the cell makes use of its genetic information, with a primary focus on the mechanisms of transcription regulation.
- They will be able to gain expertise in different techniques that can be used to study gene expression.
- They will also gain insights into the role of genes in drosophila development.

UNIT 1: GENE EXPRESSION IN PROKARYOTES

Definition of regulon, operon, *cis* and *trans* acting elements. Bacterial transcription control; induction and diauxy. Discovery and structure of lac operon. Utility of merodiploids in understanding regulation of operon. Molecular basis of repression. Isolation of repressor, assay of binding of lac operator and repressor. Effect of repressor on dissociation of RNA pol. Positive control of lac operon; mechanism of action of CRP/CAP, transcription activation by recruitment, characterization of binding of cAMP-CAP-DNA. Activation of lac PI transcription by CAP-cAMP. Catabolite repression, inducer exclusion and prevention mechanism. Anatomy and regulation of arabinose and tryptophan operons. Riboswitches; discovery and models of riboswitch action. Phage strategies; Regulatory cascade controlling lytic development. Functional clustering of phage genomes. Antitermination in lambda phage, maintenance of lysogeny by lambda phage. Characterization of λ-repressor-DNA binding, molecular properties of λ-repressor, establishment of lysogeny. Sigma switching in phage infection. **10Hours**

UNIT 2: GENE EXPRESSION IN EUKARYOTES

Stages of regulation of gene expression in eukaryotes; Chromatin structure and its effect on transcription. Nucleosome positioning; SV 40 mini chromosome, experimental location of

nucleosomal positions; DNase hypersensitive sites and mapping. Locus control regions. Histone modifications; Acetylation of histone tails. Identification of histone acetyl transferases (HATs). Properties and roles of P55 and Gcn-5 HATs. Histone deacetylases; experimental demonstration of HDACs in repressor complexes. **06Hours**

UNIT 3: CHROMATIN REMODELING

Major classes of remodeling complexes; assay of remodeling; ChIP. Composition of SWI2/SNF2 and ISWI complexes. Model of SWI2/SNF2 mechanism. Remodeling in yeast HO gene and human IFN-β promoter. Histone code. Heterochromatin silencing; chromo and bromo domains, histone methylation, HMTases, SFR and RAP-proteins. Transcription elongation through nucleosomes; FACT and PARP. **06Hours**

UNIT 4: TRANSCRIPTIONAL ACTIVATORS

Classification, structure and function, domains of activators. DNA binding motifs; Zn fingers- Gal 4 activator of yeast. Nuclear receptor- structure and function of glucocorticoid, thyroid and orphan receptors. Domains of nuclear receptors; homeo, bZIP and bHLH domains. Modularity of domains of activators; chimeric transcription factors- Gal4-LexA, two hybrid assay. Dimerization of activators, modular arrangement of enhanceosomes. Recruitment of TFIID and holoenzyme; evidence, role of enhancers, interaction between enhancer and promoter-control region of human metallothionine gene. Insulators-working, insulator bodies, Detection of transcription factors. Co-activators and mediators; discovery of mediators- mediators factors; activation of CRElinked gene model for nuclear receptor activation. Regulation of activity of transcription factors-phosphorylation, ubiquitination, sumoylation and acetylation. **08 Hours**

UNIT 5: REGULATION OF GENE EXPRESSION VIA STABILITY OF mRNA

Casein mRNA and transferring-receptor mRNA, gel mobility shift assay for IRE binding protein, model for TFR mRNA destabilization by iron. RNA interference; post transcriptional gene silencing (PTGS) and quelling. Definition, mechanism of RNAi. Classical experiments with petunia and C. elegans. Simplified model, composition and function of Dicer and RISC. Role of Argonaute. siRNAs, role of RNAi machinery in heterochromatin formation and gene silencing-EF1A gene. miRNAs; control of gene expression by miRNAs example and experimental proofs, pathways of gene silencing by miRNA. **08Hours**

UNIT 6: MOLECULAR BIOLOGY OF DROSOPHILA DEVELOPMENT

Overview of *D.Melanogaster* development Differential development by Morphogenic gradient, dorso-ventral patterning of embryo. Regulatory DNAs, role of snail and twist proteins in patterning. Localization of biocoid and nono (oskar) mRNAs in embryo, Regulation of

segmentation genes expression by bicoid. Regulation of hunchback expression, and gap genes, production of segmentation stripes, Expression of eve gene, and eve stripe-2. **06 Hours**

UNIT 7: TECHNIQUES FOR ANALYZING GENE EXPRESSION

Northern blots; S1 mapping of 5' and 3' ends of transcripts. Primer extension, and G-less cassette transcription, measuring in-vivo transcription rate- nuclear run on transcription.Microarrays, Tilling microarrays, SAGE, and CAGE, Types of RNA sequencing, RNA seq in Differential gene expression and Massively Parallel Signature Sequencing (MPSS) and its applications. **08 Hours**

References:

1. Molecular biology and Biotechnology; 4th Edn., J.M. Walker and R. Rapley, RSC (2000).
2. Molecular Biology of Gene; Watson, J.D. et al., 5th Edn. Pearson Education; (2004).
3. LEWINS Gene XII; J.E. Krebs, E.S. Goldstein, and S.T. Kilpatrick, Jones and BarlettPublishers (2018).
4. Molecular Biology; Robert F. Weaver, McGraw-Hill (2018).
5. Epigenetics and Epigenomics; Christopher J. Payne, INTECH, (2014).
6. Gene Control; David Latchman, Garland Science (2010).
7. Molecular Cell Biology; Harvey Lodish, Arnold Berk, Chris A. Kaiser, 7th Edition, W. H.Freeman (2012).
8. Molecular Biology of the Cell; 7thEdn. Bruce Alberts et al., (2008), Garland Publications
9.Evolution of the Human Genome I, Saitou, The Genome and Genes, Naruya (Ed.)Springer (2017).
10. Nuclear Organization; Chromatin Structure and Gene Expression, Roen Van Driel and ArieP. Otte (1997) Oxford University Press.
11. Genome 2; T.A. Brown, John Wiley & sons (2002).
12. Principles of Developmental Genetics; SA Moody, Academic Press (2007).
13. Developmental Biology; S. P. Gilbert, 8th Edn. Sinauer Associates Inc. (2006).
14. Human Molecular Genetics; Peter Sudbery, (2002) Printice Hall.
15. Discovering Genomics, Proteomics and Bioinformatics, Campbell A M &Heyer L J, 2nd Edn. Benjamin Cummings, (2007).
16. Long Range Control of gene Expression; Veronica van Heyningen and Robert Hill,Academic Press (2008).

BCT 402 MOLECULAR GENETICS

4 UNITS (52 hrs)

Course outcome

- This paper highlights the scope and significance of genetics by imbibing the principles of hereditary genetic transmission and interactions of gene with environment. Students will acquire knowledge in the concepts of Mendelian genetics, their principles and gene interaction.
- Students learn about chromosomal aberrations and structure of chromosomes. It also helps students to learn the molecular aspects of transposons in relation with genetic disorders and mutations in humans.
- The paper also focuses on general understanding of the replication of different RNA viruses and their significance in pathology. It also includes a brief course on bacterial genome structure, recombination, transformation and transduction. The course also has an elementary understanding of quantitative genetics and its biochemical significance.

UNIT 1: INTRODUCTION TO GENOME

Nature of genetic material. Chromosomes and genes. Structure of chromatin; nucleosomes and higher orders of organization. Over view of classical genetic. Mutation: types of mutation, mutagens, mechanism of mutation, induction and isolation of mutants and their role in genetic studies. Complementation. **07 Hours**

UNIT 2: CLASSICAL GENETICS

Review of classical genetics; work on *Pisum sativum*, Drosophila Melanogaster, *Neurospora crass*a etc. inheritance (sex-linked and others). Population genetics, extranuclear inheritance. Sex determination, Morgan's discovery of sex linked inheritance of sex linked genes, X;linked traits in humans. Identification of sex chromosomes, XX,XY, mechanism of sex determination. X inactivation. Structure of Y chromosome.

08 Hours

UNIT 3: QUANTITATIVE GENETICS

Human quantitative traits, discontinuous traits and continuous traits, Breeding analysis, genetics basis of quantitative variation, Multiple factor hypothesis and analysis of polygenes.Genotype-Environment Interaction and models for their measurement, Population genetics, estimation of Heritability Index. **08 Hours**

UNIT 4: HUMAN GENETICS

Biochemical methods for genetic studies: Chromosome banding, Chromosome mapping based on recombination frequency data. Transposons. Transposition in human chromosomes. Overview of human genome project, mapping of human genes; techniques used, annotation of important genes. Chromosomal abnormalities.Use of SNPs for detection of diseases. **12 Hours**

UNIT 5: BACTERIAL GENETICS

Bacterial chromosomes, 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. **08 Hours**

UNIT 6: VIRAL GENETICS

Life cycles of bacteriophages, lytic cycle; replication of T- phages. Lysogeny and its regulation. Transduction; specialized, generalized and abortive. Fine structure analysis of T-phages; Benzers work, concept of cistrons.

Replication of RNA viruses- ss +RNA viruses; Picarna (Polio) and ss-RNA viruses, orthomixovirus (influenza virus). dsRNA-reovirus (Rota virus), Retroviruses; Structure and mechanism of reverse transcriptase and integrase (HIV). **09 Hours**

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. Genetics and Molecular Biology; Robert Schleif, The Johns Hopkins University Press Baltimore, (1993).
5. Discovering Genomics, Proteomics and Bioinformatics, Campbell A M &Heyer L J, 2nd Edn. Benjamin Cummings, (2007).
6. Introduction to Genetics: A Molecular Approach; T A Brown, Garland Science (2011).
7. Molecular Cell Biology; Lodish et al., 7th Edn. W.H. Freeman and Co. (2012).
8. Molecular Biology of the Cell; 7th Edn. Bruce Alberts et al., Garland Publications (2008).
9. Nuclear Organization; Chromatin Structure and Gene- Expression, Roen Van Driel and Arie P. Otte Oxford University Press (1997).
10. Principles of Developmental Genetics; S.A. Moody, Academic Press (2007).

11. The Cell; Geoffrey Cooper, and Robert E.; 5th edn. HausmanSinauer Associates (2009).
12. The Science of Genetics, George W. Burns and Paul J. Bottino (1989), Maxwell-McMillan.
13. Human Genetics; Lewis, 7th Edn. WCB & McGraw Hill (2007).
14. Essential Genetics: A Genomics Perspective; Daniel L. Hartl, 6th Edition, Jones and Barlett Learning (2012).
15. Bacterial and Bacteriophage Genetics; Edward A. Birge, 5th Edition, Springer (2006).
16. Nucleosome Histone, and Chromatin; Part-A; Carl Wu and C. Allis, Academic Press (2012).

BCT- 403 GENETIC ENGINEERING

4 UNITS (52 hrs)

Course out come

- The students able to understand the steps and methodology of cloning, the use of restriction and modification enzymes in cloning, screening employed with different vectors.
- Able to describe the methodology for construction and screening of DNA libraries, understand the principle and methodology of PCR. Describe the different modifications of PCR and their applications. Comprehend the principle of sequence analysis, viral vectors for transformation, the use of viral vectors for transformation and expression, use of different methods for transformation.
- Students gain knowledge of principle of fermentation design, describe different culture systems, able to describe the different methods used for downstream processing.
- Able to understand the preparation and application of nanobioparticles, understand the construction and application of biosensors.

UNIT 1: INTRODUCTION

Introduction to cloning procedures. Isolation of nucleic acids and their characterization – vectors and genomic DNA. **02 Hours**

UNIT 2: 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, Alkaline Phosphatases and Poly nucleotide kinases(PNK) 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. **06 Hours**

UNIT 3: CLONING VECTORS AND CLONING

Desirable properties of vectors,basic properties of plasmids, plasmids as vectors. Directional cloning in plasmid vectors (pUC), blunt end cloning in plasmids, use of linkers and adapters in cloning.Preparation of competent cells and transformation of cloning host, electroporation, Screening colonies using X-gal and IPTG (α-complementation), screening by hybridization,restriction digestion.

Bacteriophage lambda vectors- Insertional and replacement lambda vectors, transfection, in vitro packaging, screening recombinant phages. Cloning in M13 vector and COSMID vectors and their applications.

Expression vectors: Characteristics of expression vectors, bacterial expression vectors. Super vectors-characteristic features and utility of BAC and YAC **08 Hours**

UNIT 4: GENOMIC AND CDNA LIBRARIES

Outline of methodology for genomic library construction, creation of genomic libraries using lambda and cosmid vectors. Growth, evaluation, storage and amplification of genomic libraries.cDNA libraries; methodology, screening cDNA libraries- hybridization, screening with antibodies.

05 Hours

UNIT 5: PCR

Discovery, principle and procedure, variants of PCR- Reverse transcriptase-PCR, long PCR, differential display RT PCR, inverse PCR, multiplex PCR, real-time PCR, Cloning PCR products, TA-cloning, Application of PCR- PCR in screening clones, colony PCR, PCR-based methods for mutagenesis (overlap-extension, megaprimer) , PCR in diagnostics

05 Hours

UNIT 6:SEQUENCING

Principle of DNA sequencing, automated sequencing, extending the sequence, shot gun sequencing. Analysis of sequence data; annotation, ORF, exon-intron boundaries, identification of genes and their products. **05 Hours**

UNIT 7:GENETIC ENGINEERING IN ANIMAL CELLS

Over view of strategies, transfection methods-phospholipids as delivery vehicles, electroporation and direct transfer, transient and stable transformation, Cotransformation and selection of stable transformants, selectable markers for animal cells. Mammalian plasmid expression vectors, reporter genes. Gene transfer by viral vectors- adeno and Baculo virues, retroviral vectors.

06 Hours

UNIT 8:GENETIC ENGINEERING IN PLANTS

Plant cell, protoplast, and callus culture and their manipulations. Agrobacterium-mediated transformation, properties of Ti plasmid, Ti-plasmid derivatives as plant vectors (disarmed T-DNA), cointegrate and binary vectors, selectable markers for plants, analysis of transgene expression in plants. Plant expression vectors; CaMV and TMV vectors. Gene transfer techniques in plants-Direct gene transfer, protoplast transformation and particle bombardment. **06 Hours**

UNIT 9: BIOPROCESS TECHNOLOGY

Fermentation: Fermentation process design, operation and characteristics of fermentation processes; batch, fed-batch and continuous culture systems, instrumentation and bioprocess control. **03 Hours**

UNIT 10: DOWNSTREAM PROCESS

Introduction to various downstream process operations in biopharmaceutical manufacturing such as centrifugation, filtration, cell disintegration etc.

03 Hours

UNIT 11: NANOBIOTECHNOLOGY

Definition and methods of preparation of nano-bioparticles. Applications in drug designing and drug delivery. Biosensors – Construction, uses in industrial and environmental processes and medical applications. **03 Hours**

References:

1.Molecular Cloning; A laboratory manual; Michael R. Green, CSHL Press (2012).
2. Molecular Cell Biology; Lodish et al., 7th Edn. 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 and Techniques of Biochemistry and Molecular Biology; 7th Edn. Keith Wilson and John Walker (2010).
6. Principles of Gene Manipulations; 6th Edn. S.B. Primrose, R.M. Twyman, and R.W. Old, Blackwell Science (2012).
7. Gene Cloning and DNA analysis- An Introduction; T. A. Brown, 5th Edition, Wiley-Blackwell Publishing (2006).
8. Molecular biology and Biotechnology; 4th Edn., J.M. Walker and R. Rapley, RSC (2000).
9. Plant Biotechnology and Agriculture; Arie Altman and Paul Hasegawa Academic Press (2011).

BCT 404 – MOLECULAR SIGNALLING

4 UNITS (52hrs)

Course outcome

- The present course has been designed to expose the students to cell signaling, its components and relation with cancer
- This paper introduces the Biology concepts of cell signaling at molecular level.
- The students learn about signaling in microbes, animal system, and their pathways
- To understand mechanism of action of signalling pathway mediated by protein and enzymes.
- To understand genetic basis of cancer cells: oncogenes, tumor suppressor genes and gain of function mutations.
- By the end of the course, the student has a better appreciation for the role of cell signaling in diagnostics and therapeutic applications

UNIT 1: PRINCIPLE OF SIGNAL TRANSDUCTION

Introduction, over view of signal transduction pathways, major types of signaling mechanisms, mechanisms of signal transduction; extracellular signaling, Cell surface receptors, major class of cell surface receptors, Intracellular signaling. Intracellular signaling proteins (adaptors, activators, bifurcators, integrators, effectors, etc.) signal amplification. Second messengers- Calcium cAMP, cGMP, phosphoinositides, effectors- Adenylate cyclase, guanylate cyclase, Phospholipase- C and NO. **06 Hours**

UNIT 2: G-PROTEIN COUPLED RECEPTORS

G-protein coupled receptor system: Transmembrane Receptors, Domains of Transmembrane (TM) receptors, and Regulation of Receptor Activity. GTPase Superfamily: General Functions and Mechanism, G-domain as Common Structural Element of the GTPases. General mechanism of the activation of effectors molecules associated with G-protein-coupled receptors, G-protein coupled receptors that activate or inhibit adenylate cyclase, G-protein coupled receptors that activate

phospholipase-C, and G-protein coupled receptors that regulate ion channels. Signaling transcriptional activation by CREB, regulation of GPCRs, examples (epinephrine, glucagon), GPCRs in sensory perception. GPCRs as drug target. **06 Hours**

UNIT 3: CELL SIGNALING PATHWAY

Signaling proteins: Ser/Thr-Specific Protein Kinases and Protein Phosphatases Signal transduction of vision: structure and function of rhodopsin, primary events in visual excitation, cGMP and transduction in generation of nerve impulse, colour vision. Receptor Tyrosine kinase {(RTK): Ras-MAP Kinase pathway [EGF, IGF, insulin]}, transcriptional activation by MAP kinases (Erk – fos – jun – cyclin – D), IP3 and DAG in RTK signaling pathways, examples (EGF, insulin) Intrinsic enzyme / cytokine receptors and 4) specificity of protein kinases. **08 Hours**

UNIT 4: NERVE SIGNALING

Origin and mechanism of actions of neurotransmitters-Acetylcholine, catecholamine, serotonin; aminoacids glutamate, aspartate, GABA and glycine and neuropeptides (somatostatin/enkephalins).

Structure, subtypes and functions of receptors of ACh, GABA, Glycine, Serotonin and glutamate and peptide neurotransmitters, activation by ligands & interaction with effectors. Role of agonists &antagonists of neurotransmitters. Mechanism of synaptic vesicle cycle-exoand endocytosis of synaptic vesicles. Biochemical basis of neurological diseases. **12 Hours**

UNIT 5: CELL CYCLE

Overview of cell cycle, Growth factors and cytokines, growth phases and check points of cell cycle (DNA replication and spindle- attachment checkpoint) and their regulation. Cyclins and cyclin-dependent kinases. Promotion of G1/S by growth factors, cell cycle arrest at G1, role of Rb proteins in cell cycle arrest, entry of cell from G2 to M – phase Role of M – Cdk, MPF. Regulation of M-phase (role of mitogen, survival factor and TGF- β). Role of ubiquitin.

Stem Cells: Embryonic and adult stem cells; unique properties, and potential applications.

Apoptosis: Discovery, intrinsic and extrinsic pathway, morphological changes, signal transduction via TNF pathway, Fas pathway. Role of caspases, Distinguishing apoptotic cells from necrotic cells. Hyperactive apoptosis and treatment in HeLa cells

Cancer: Introduction, causes and symptoms, pathophysiology, diagnosis, prevention and treatment. Etiology of breast, colon and prostate cancer Signaling cascades in cancer (MAP kinases, Ras pathways, JAK-STAT and TGF-β pathways). **20 Hours**

References:

1. Molecular biology and Biotechnology; 4th Edn., J.M. Walker and R. Rapley, RSC (2000).
2. Molecular Biology of Gene; Watson, J.D. et al., 5th Edn. Pearson Education; (2004).

3. LEWINS Gene XII; J.E. Krebs, E.S. Goldstein, and S.T. Kilpatrick, Jones and BarlettPublishers (2018).
4. Molecular Biology; Robert F. Weaver, Mc Graw-Hill (2018).
5. Epigenetics and Epigenomics; Christopher J. Payne, INTECH, (2014).
6. Gene Control; David Latchman, Garland Science (2010).
7. Molecular Cell Biology; Harvey Lodish, Arnold Berk, Chris A. Kaiser, 7th Edition, W. H.Freeman (2012).
8. Molecular Biology of the Cell; 7thEdn. Bruce Alberts et al., (2008), Garland Publications
9.Evolution of the Human Genome I, Saitou, The Genome and Genes, Naruya (Ed.)Springer (2017).
10. Nuclear Organization; Chromatin Structure and Gene Expression, Roen Van Driel and ArieP. Otte (1997) Oxford University Press.
11. Genome 2; T.A. Brown, John Wiley & sons (2002).
12. Principles of Developmental Genetics; SA Moody, Academic Press (2007).
13. Developmental Biology; S. P. Gilbert, 8th Edn. Sinauer Associates Inc. (2006).
14. Human Molecular Genetics; Peter Sudbery, (2002) Printice Hall.
15. Discovering Genomics, Proteomics and Bioinformatics, Campbell A M &Heyer L J, 2nd Edn. Benjamin Cummings, (2007).
16. Long Range Control of gene Expression; Veronica van Heyningen and Robert Hill,Academic Press (2008).

BCP – 405: GENETIC ENGINEERING AND PROTEIN CHEMISTRY

(4 Credits)

Course outcome

- The students able to understand the steps and methodology of cloning, the use of restriction and modification enzymes in cloning, screening employed with different vectors.
- Able to understand the principle and methodology of PCR.
- Learn the protein purification techniques by various methods, separation by electrophoresis techniques and determining kinetic characteristics

Genetic Engineering

1. Isolation of bacterial genomic DNA
2. PCR amplification of specific fragment gene
3. Ligation of gene into plasmid
4. Preparation of Competent cells.
5. Transformation of DNA by $CaCl_2$ method (recombinant vectors – plasmids / phages).
6. Restriction digestion of plasmid DNA.
7. Characterization of clones.
8. Purification of recombinant protein

Protein Chemistry

1. Extraction and isolation of enzymes (phosphatases / esterases / amylases) from Insect / Microbial / Plant sources.
2. Fractionation by Ammonium sulfate, acetone and pH precipitation
3. Ion exchange chromatography.
4. Gel filtration.
5. Kinetic characterization of the enzyme.
6. Analysis of purity of the isolated enzyme protein by NATIVE and SDS PAGE.

Open elective for Non-Biochemistry PG students
BCHOET – 304: Biochemistry in Daily Life

4 units (39 hrs)

Course outcome:

- The students will acquire an understanding of the basics of the Biochemistry of unicellular and multicellular organisms and the difference between plant and animal cells.
- To understand the requirement of food and nutritional importance in day-to-day life to maintain good health. Importance of Nutraceuticals, Prebiotics, and probiotics to improve health & diseases. Role of functional food & traditional Indian food to fight against non-communicable diseases.
- To gain knowledge in the food industries, processing of food, chemicals in the preservatives, toxicology of chemicals. Role of sweetening agents, food colours, flavoring agents.

- To know the importance of enzymes in food processing unit, importance & characteristics of fortification

Definition of Biochemistry: Definition of life, The different forms of life, micro-organisms to human beings. Building blocks of life. Introduction to the common macro- and micro- constituents of unicellular and multicellular organisms. Differences encountered in plant and animal kingdoms. **4 hrs**

Food and Nutrition: Importance of food for existence of life. Modes of nutrition in life forms – Comparable and contrasting features. **2 hrs**

Human Health and Disease: Nutrition (Health), definition, classification, food and non food sources.

Nutraceuticals; use of nutraceuticals in health sciences. Role of omega-3 fatty acids, carotenoids, dietary fiber, phytoestrogens; glucosinolates; organosulphur compounds in health and disease (prevention and control). **5 hrs**

Prebiotics and probiotics: usefulness of probiotics and prebiotics in gastro intestinal health and other benefits. Beneficiary microbes; prebiotic ingredients in foods; types of prebiotics

Functional foods: Definition, benefits and sources of functional foods in Indian diet. Effects of processing conditions and storage. *Development of nutraceutical;*. Process of developing-preclinical & clinical studies. **7 hrs**

Food additives: Definitions, functions and uses in processed food products. Chemical, and toxicological aspects of acid, base buffer systems, salts and chelating/sequestering agents, leavening agents, antioxidants, emulsifying and stabilizing agents, anti-caking agents, thickeners, firming agents, flour bleaching agents and bread improvers. **Sweetening agents:** Artificial sweeteners, composition, uses. Natural and synthetic colors**,** food Flavors, Spices and flavoring constituents, flavors in food industries. **7 hrs**

Enzymes: Introduction classification and essentiality to life forms. Use of enzyme in beverages-fruit juices, beer, wine, and distilleries; dairy, baking, oils and fats, plantation products, animal products. Domestic use products like detergents. Textiles-Denim processing. Leather industry. **6 hrs**

Food processing and fortification: Principles, objectives and rationale, selection and basis of fortificants. Technology of fortifying cereal products. Fortification of bread, pasta, noodles, biscuits, and breakfast cereals. Beverages; importance of beverage fortification, Health benefits of fortification. Characteristics of fortificants and method of fortification, Bioavailability, Organic Vs inorganic salts. . **8 hrs**

References

1. Biochemistry Ed. Donald Voet & Judith G. Voet, John Wiley & Sons, Inc.(2010).
2. Lehninger- Principles of Biochemistry; D.L.Nelson and M.M. Cox, 7th Edn. MacMillan Publications (2017).

3. Nutrition: Science and Applications, 3rd Edn. Lori A. Smolin, Mary B. Grosvenor, Wiley (2013).
4. Introduction to Human Nutrition, 2nd Edn. Michael J. Gibney, Susan A. Lanham-New, Aedin Cassidy, Hester H. Vorster, Wiley-Blackwell (2009).

5. Nutrition: Everyday Choices, 1st Edition; Mary B. Grosvenor, Lori A. Smolin Wiley (2006).
6. Bioactive Food as Dietary Interventions for Liver and Gastrointestinal Disease; Watson Elseveir (2012).
7. Food, Nutrition and Health. Tapsell L. Oxford University Press (2010).

***