BANGALORE UNIVERSITY

Syllabus

For

M. Sc. Biochemistry
Choice based credit system (CBCS)

With effect from 2014 – 15

Department of Biochemistry,
Central College Campus
Bangalore – 560 001

FOREWORD

As per the directives from the University, the syllabus for M. Sc. Degree course in Biochemistry had to be prepared in accordance with the guidelines provided by the University.

The teaching faculty member of the Department of Biochemistry participated in the discussions for syllabus preparation. The departmental council met three times on 9, 15, and 19 July, 2014 to deliberate on the topics and subjects for the syllabus. In order to conform to the UGC Model Curriculum for development of interdisciplinary skills in students by linking general studies with professional courses and allowing horizontal and vertical mobility, as well as local needs, the Biochemistry syllabus has been redesigned. After studying the course content for the Choice Based Credit System (CBCS), the Draft syllabus was approved by the Departmental Council in its meeting held on 23rd July, 2014. The draft syllabus was placed before the Board of Studies in Biochemistry (PG) for approval on 28.07.2014.

CHAIRMAN
Department of Studies in Biochemistry
Central College Campus
Bangalore University
Bangalore -560001

Proceedings of the meeting of the Board of Studies in Biochemistry (PG) held on 28th July, 2014 in the Department of Biochemistry, Central College Campus, Bangalore University, Bangalore -560001.

The meeting of the Board of Studies in Biochemistry (PG) was held on Monday, the 28th July, 2014 at 10.30 am in the Library of Department of Chemistry to approve the M.Sc. CBCS 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:

1. Dr. Paramahansa V Salimath — External Member
   Dept. of Biochemistry & Applied Nutrition
   CFTRI, Mysore-570013

2. Prof. N. Ramachandra Swamy
   Chairman, Dept. of Biochemistry, — Chairman (BOS)
   Bangalore University
   Bangalore -560001

3. Dr. V. R. Devaraj, — Member
   Dept. of Biochemistry,
   Bangalore University
   Bangalore -560001

4. Dr. K.R. Siddalinga Murthy — Member
   Dept. of Biochemistry,
   Bangalore University
   Bangalore -560001

5. Dr. H. D. Ramachandran — Member
   Dept. of Biochemistry,
   Bangalore University
   Bangalore -560001

6. Prof. T.B. Karegoudar, — External Member
   Dept. of Biochemistry
   Gulbarga University, Glubarga — ABSENT

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: 14 + payment seats (05)

Admission: As per the prevailing University regulations.

SCHEME OF STUDY AND EXAMINATION

I to IV SEMESTER M. Sc. BIOCHEMISTRY COURSE

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	Analytical Biochemistry – I	4	3	30	70	100	4
BCT – 104	General Physiology	4	3	30	70	100	4
BCSCT – 105	Nutrition	3	3	30	70	100	2
BCP – 106	Gen. Biochemistry – I	8	4*	30	70	100	4
BCP – 107	Gen. Biochemistry – II	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 – II	4	3	30	70	100	4
BCT – 203	Metabolism – I	4	3	30	70	100	4
BCT – 204	Membrane Biochemistry	4	3	30	70	100	4
BCSCT – 205	Microbiology	3	3	30	70	100	2
BCP – 206	Immunochemical & Biochemical techniques	8	4*	30	70	100	4
BCP – 207	Enzymology	8	4*	30	70	100	4
					Total	**700**	**26**

Third Semester							
Paper Code	**Title of the paper**	**Contact hours**	**Exam hours**	**Marks**			**Credits**
				IA	**Exam**	**Total**	
BCT – 301	Molecular Biology – I	4	3	30	70	100	4
BCT – 302	Molecular Physiology	4	3	30	70	100	4
BCT – 303	1. Metabolism – II 2. Plant Physiology	4	3	30	70	100	4
OET – 304	Open Elective**	4	3	30	70	100	4
BCP – 305	Clinical Biochemistry	8	4*	30	70	100	4
BCP – 306	Molecular Biology	8	4*	30	70	100	4
					Total	**600**	**24**

** Non- Biochemistry Paper

Fourth Semester							
Paper Code	**Title of the paper**	**Contact hours**	**Exam. hours**	**Marks**			**Credits**
				IA	**Exam**	**Total**	
BCT – 401	Molecular Biology – II	4	3	30	70	100	4
BCT – 402	Biochemical Genetics	4	3	30	70	100	4
BCT – 403	Biotechnology	4	3	30	70	100	4
BCT – 404	Immunology and Toxicology	4	3	30	70	100	4
BCP – 405	Genetic Engineering and Protein chemistry	8	4*	30	70	100	4
BCPR – 406	Project work	8	Report	30	70	100	4
Total						**600**	**24**

Scheme for Continuous Evaluation:

Theory each Paper	
Attendance:	5 Marks
Tests[#]:	25 Marks
Total:	**30 Marks**

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

Practical (each Practical)	
Attendance:	5 Marks
Tests[#]:	**20 Marks**
Records:	5 Marks
Total:	**30 Marks**

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

FIRST SEMESTER M. Sc. BIOCHEMISTRY

BCT – 101: Biophysical and Bioorganic Chemistry

4 units (52 hrs)

Properties of water: Physical and chemical properties of water, ionization and ionic product of water, structure of liquid water and ice. Unusual properties of water. Hydrophilic, hydrophobic and amphipathic molecules in aqueous solution. Effect of solutes on colligative properties of water. Importance of water in biological systems with special reference to the maintenance of native structure of biological molecules. 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).

6 hrs

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. **5 hrs**

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

Mechanism of Bio-organic reactions: Introduction, meaning of the term, kinetic and non-kinetic. Fundamental aspects: 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, addition, elimination and rearrangements. Energy profiles of reactions, transition state theory, kinetically and thermodynamically controlled reactions. Reactions SN^1, SN^2, SN^1 neighbouring group participation. E_2, E_i, Curtin-Hammett principle. Electrophilic addition to C=O, detailed discussion of all aspects of aldol condensation, related condensations, Michael addition. Esterification and hydrolysis.

12 hrs

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

Free radicals: Introduction, formation – photolysis, thermolysis, redox reactions, radical reactions with biomolecules. **4 hrs**

Heterocyclic systems: Occurrence in biological systems, structure and properties of furon, pyrrole. Indole, thiazole, imidazole, pyridine, pyrimidine, purine, quinone, pteridine and isoalloxazine containing biomolecules. **8 hrs**

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). **6 hrs**

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 Frifielder. 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: Brief review of configurational and conformational aspects of carbohydrates. Structure, properties and importance of structural (cellulose and chitin) and storage polysaccharides (starch and glycogen), glycosaminoglycans, cardioglycosides and bacterial cell wall polysaccharides. Structure elucidation of polysaccharides (starch, glycogen and cellulose). Glycoproteins – structure and functions, blood group antigens, sequence analysis of oligosaccharides. Lectins – characteristics and functions in biological system.

10 hrs

Lipids: Lipid classification, brief account of the chemical properties and structure of lipids (without structure elucidation) & biological role of the following: fatty acids, acyl glycerols, phospholipids, plasmalogens, sphingolipids, glycolipids, steroids, eicosanoids – prostaglandins, thromboxanes, & leukotrienes, leptin and visfatin. **7 hrs**

Amino acids and Proteins: Review of classification and structure of amino acids, acid – base properties of amino acids. Non – standard, non–protein and biologically active amino acids. UV-

light absorption property of amino acids. Ionic properties of peptides and proteins. Naturally occurring peptides. Peptide synthesis– reactive ester method and modified Merrifield solid phase synthesis.

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

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

Tertiary structure: Forces stabilizing tertiary structure of proteins. Protein denaturation and renaturation.

Quaternary structure and symmetry: Structure and function of myoglobin and hemoglobin. Cooperative mechanism of oxygen binding to hemoglobin. Abnormal hemoglobin– sickle-cell hemoglobin.

20 hrs

Protein folding pathways: Protein dynamics – kinetics of protein folding and disulfide bond formation, molecular chaperones and protein disulfide isomerase. Prediction of secondary and tertiary protein structure. Disease related to protein folding – Alzheimer's and mad cow disease.

3 hrs

Nucleic Acids: Structure and properties of Nucleosides and Nucleotides. Structure of nucleic acids– primary, secondary and tertiary structure of DNA. Isolation, fractionation and characterization of nucleic acids. Properties of nucleic acids in solution. Secondary structure of tRNA and role of secondary structure in mRNA stability. Chemical synthesis of oligonucleotides (phosphate and phosphite method). Nucleic acid sequencing – Maxam and Gilbert and Sangers method. Rapid sequencing methods and new generation DNA sequencers.

12 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).

BCT- 103: Analytical Biochemistry – I

4 Units (52 hrs)

Introduction to Biochemistry: **1 hr**

Overview of Biochemical Investigations: Introduction to biochemistry, outline of strategies in biochemical investigations employing whole animal studies, isolated organs, tissues, and cell cultures. Specific investigations with isolated organelles;mitochondria and ER. Investigations with microorganisms and their mutants yeast, *Ceanorhabditis elegans, Arabidopsis thaliana* and *Drosophila melanogaster* as model specimen for biochemical investigations. Basic equipments and 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 ulture in biochemical investigations.

Extractions; Preparation of extracts for biochemical investigations, physicochemical properties of metabolites and drugs extracts from biological materials. Physico-chemical properties of solvents, solubility and missibility, ionic bonds, and salting out. Partition, ionization, buffering and their effect on extraction. Choice of solvent for solvent extraction, mixed solvents, solid phase extraction.

9 hrs

Microscopic techniques: Review of light microscope, resolution of microscopes, Optical contrast, phase contrast, and dark field microscopy, 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 **s**canning electron microscopy (SEM), Transmission electron microscopy (TEM), and cryo-electron microscopy. 3-D images, negative staining, single particle reconstruction.

5 hrs

Fluorescence Microscopy: Fluorophores, principle and applications of fluorescence microscopy, design and uses of Epifluorescence microscoy, and immuno-fluorescence microscopy. Imaging live cells and tissues; time lapse imaging, fluorescence stains of living cells, reporter molecules, multidimensional imaging. Measuring cellular dynamics; calcium imaging in live cells, fluorescence recovery after photo bleaching (FRAP), Fluorescence

resonance energy transfer (FRET). Use of ion-selective electrodes, light emitting indicators and optical tweezers in study of cellular dynamics.

5 hrs.

Centrifugation: Principle of centrifugation, the Swedberg equation, types of centrifuges and rotors. Density gradient centrifugation- Caesium chloride and sucrose density gradients; examples of separations, Sub-cellular 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., oligomerization of valinomycin, 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

Manometry: Instrumentation, types of manometry; Warburg constant volume manometer, Gilson's differential respirometer, applications.

3 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 radio-labeled compounds, specific activity, radio-labeled nucleotides, metabolites. Pulse chase experiments.

8 hrs

Quantitative biochemical measurements: Analytical considerations and experimental errors, nature of experimental errors- random and systemic errors. Identification of systemic errors, SOPs. Performance of analytical methods, precision, accuracy, detection limit, analytical range, specificity, sensitivity, and robustness. Gaussian distribution (normal) of data, quantification of precision by standard deviation, coefficient of variation and variance, (data to be provided for calculation of each parameter). Assessment of accuracy; Population statistics- confidence limits and confidence intervals, student's t-test, standard error of mean, examples for calculation. Q-tests, examples and applications, Null hypothesis, use of t-test to validate analytical methods- unpaired, paired, one-sample, two-sample tests with examples. Calibration methods; Least mean square method of fitting straight line to data with example. Correlation and regression analyses. ANOVA, one way and two-way ANOVA.

9 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 7^{th} Edn. Keith Wilson and John Walker, Cambridge University Press, (2010).
4. Principles of Gene Manipulations; 6^{th} 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. Choosing and Using Statistics; A Biologist Guide, Clavin Dythan, Blackwell Scientific (1999).
13. Basic Mathematics for Biochemists; Cornish Bowden, Oxford University Press (1998),.
14. Biophysical Tools for Biologists *In Vivo* Techniques; John Correia H. Detrich, III Elsevier (2008).
15. Recent Advances in Electron Microscopy- Part-A; B.V. Venkartarmaprasad, and Steve Ludtke, Academic Press (2010).
16. Recent Advances in Electron Microscopy- Part-B; B.V. Venkartarmaprasad, and Steve Ludtke, Academic Press (2011).
17. Introduction to Electron Microscopy for Biologists; Terry Allen, Academic Press (2008).

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, inter-cellular 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 G-actin, role of Thymosin-B4, Profilin and Cofilin in polymerization, structural and functional property of F-actin, Capping proteins and assembly of actin filaments, branched and unbranched

filament assemblies, Arp2/3, 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 potent ial. 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, neuro-muscular 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. Gastro-intestinal hormones. Digestion, absorption and transport of carbohydrates, proteins, lipids, nucleic acids and vitamins. Liver – structure and functions. Detoxification mechanisms. Liver function tests. **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 vitamin K, clot dissolution, anti-clotting factors, Formation, counting and functions of erythrocytes, leukocytes and thrombocytes. Lymph, Cerebro spinal 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, respiratory mechanism of acid-base balance. **5 hrs**

Excretory System: Mechanism of urine formation and composition of urine. Urine analysis for abnormal constituents, tubular function tests. 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. **7 hrs**

References

1. The Cell, Copper, Geoffery, M., Oxford University Press, (2001)
2. Text Book f 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).

BCSCT – 105: Nutrition

4 units (39 hrs)

Carbohydrates: Occurrence and physiological functions, factors influencing metabolism. Lactose 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.

Lipids: Concepts of visible and invisible fats. EFA, SFA, MUFA, PUFA- sources and physiological functions. Role of lipoproteins and cholesterol, triglycerides in health and disease.

Proteins: Concepts of essential and non-essential amino acids- their role in growth and development. Physiological functions of proteins. Requirements, nitrogen balance concept. Protein efficiency ratio. Methods for evaluating protein quality. Protein energy malnutrition-clinical features and biochemical changes. **12 hrs**

Macro-minerals: Calcium, Phosphorus Magnesium, Sodium, Cobalt, Potassium, Chloride.
Micro minerals: Iron, Zinc, copper, selenium, chromium, iodine, manganese, Molybdenum and fluoride.
Ultra trace minerals: Arsenic, Boron, Nickel, Silicon, Vanadium & cobalt: Digestion & absorption, Functions, Toxicity, interaction with other nutrients. RDA and food sources.

6 hrs

Vitamins and Energy metabolism: Fat soluble vitamins: RDA. Vitamin- A, vitamin- D, E & K. Water soluble vitamins: Vitamin-C, Thiamine, Riboflavin, Niacin, Pantothenic acid, Biotin, Folic acid, Vitamin-B12, Vitamin-B6 (Digestion, absorption and transport and excretion, functions, interaction with other nutrients (if any), Deficiency and toxicity, major sources, Assessment of nutritive value and analysis in food material.

Energy metabolism: Basal and resting metabolism- influencing factors. Methods to determine energy requirements & expenditure. Thermo genesis, adaptation to altered energy intake, latest concepts in energy requirements and recommendations for different age groups. BMR and methods of BMR determination. Factors affecting BMR. Energy requirements for different physical activities. Specific dynamic action (SDA) of food.

Regulation of food intake: role of hunger and satiety centers, effect of nutrients.

Basis for computing nutrient requirements: latest concepts in dietary recommendations, RDA-ICMR and WHO: their uses and limitations.

10 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.

4 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. **7 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).

BCP – 106: Gen. Biochemistry – I (4 Credits)

1. Preparation of buffers; Acetate, phosphate and tris buffer.
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. Isolation of potato starch / liver glycogen.
6. Hydrolysis of starch / glycogen and estimation of its purity by H.J. method.
7. Hydrolysis of starch / glycogen and estimation of its purity by Somogy's method.
8. Analysis of water: estimation of calcium and magnesium by EDTA method.
9. Determination of pI of casein from milk.
10. Determination of phytic acid.
11. Estimation of vitamin C by dichlorophenol indophenol method.

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 7^{th} Edn. Keith Wilson and John Walker, Cambridge University Press, (2010).
4. Biochemistry LabFax, Ed. J.A.A. Chambers and D. Rickwood,, Blackwell Science, (1993),
5. Protein Purification Applications, S.L.V. Harris and Angal IRL Press, (1990)
6. Laboratory Techniques in Biochemistry and Molecular Biology, Work and Work Vol. I & II, North Holland, (1969).
7. Physical Biochemistry. Kansal Edward Van Halde. Prentice Hall.

BCP – 107: General Biochemistry – II (4 Credits)

1. Absorption spectra of proteins and nucleic acids and determination of molar extinction coefficient.

1. Estimation of reducing sugars (lactose in milk) by DNS method.
2. Estimation of sugars by Phenol – Sulfuric acid / Anthrone method.
3. Estimation of sugars by Nelson's method.
4. Estimation of protein by Lowry's method.
5. Estimation of inorganic phosphate by Fiske-Subbarao method.
6. Estimation of tyrosine by Millon's method.
7. Estimation of Lysine.
8. Estimation of Tryptophan.
9. Isolation of nucleic acid from cauliflower / sheep liver.
10. Estimation of DNA by Diphenylamine method.
11. Estimation of RNA by Orcinol method.

References

1. Biochemical Calculations, Irwin H.Segel (1976) 2 nd Ed. Jhon Wiley and Sons.
2. Methods in Enzymology; Colowick , S.P. et al., [Eds.] (1987) Vol. 152, Academic Press.

3. Modern Experimental Biochemistry R.F.Boyer [Ed.] (1986) Addition Wesley.
4. Methods of Enzymatic Analysis; Berg Meyer (1974) Vol. 1-X,
5. Analytical Biochemistry; D.J.Holme and H. Pick Longman (1983).
6. Principles and techniques of Biochemistry and Molecular Biology; Keith Wilson and John Walker; 6th Edn. (2005) Cambridge University Press.

Second Semester M. Sc. Biochemistry

BCT – 201: Enzymology

4 units (52hrs)

Introduction to Enzymes: Nomenclature and classification of enzymes. Specificity and active site. Fundamentals of enzyme assay – enzyme units, coupled kinetic assay, immobilized enzymes. Enzyme localization. Criteria of purity of enzymes.
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) an and super reactive amino acid chains (chymotrypsin and glutamate dehydrogenase). The 3-D structural features of active sites as revealed by X-ray crystallographic and chemical studies (chymotrypsin trypsin, elastase and triose phosphate isomerase). Site directed mutagenesis.

7 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), and multi-enzyme complexes (pyruvate dehdrogenase complex). Metal–activated and metallo-enzymes (mechanism of action of pyruvate kinase, creatine kinase, superoxide dismutase & carboxypeptidase – A). **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 B_{12}. **6 hrs**

Kinetics of enzyme-catalyzed reactions: Methods used in the 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. Integrated velocity

equation. Haldane equation. King-Altman procedure for deriving the rate equation. Effect of pH & temperature on enzymatic reactions, Arrhenius plot, determination of activation energy. **9 hrs**

Enzyme Inhibition: Types of reversible inhibitors; competitive, non-competitive, uncompetitive, and mixed inhibitors. Partial inhibition, substrate inhibition and allosteric inhibition. Irreversible inhibition. **6 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 characterisation of bisubstrate 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. Study of ATCase as typical allosteric enzyme. Other mechanisms of metabolic regulation. **7 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 – II

4 units (52hrs)

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.

Modes of chromatography: Ion exchange, major ion exchange matrices, elution in ion exchange chromatography. Examples of cation and anion exchangers, chromate-focusing. Gel filtration: matrix used fractionation range and matrices, determination of native mass of protein by gel filtration. 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.

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).

15 hrs

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. G.L.C; principle and application.

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

Capillary electrophoresis: Principle, instrumentation, electro-osmotic flow, free solution capillary electrophoresis. Choice of buffers and ionic strength. Organic modifiers electro chromatographic-electrically driven HPLC. Capillary sample introduction and detection in capillary electrophoresis.

Electrophoresis: Historical developments, principle, non-denaturing PAGE, activity staining for enzymes, zymogram, denaturing electrophoresis (PAGE), SDS-PAGE, SDS-PAGE in reducing conditions, chemical cross linking of proteins urea electrophoresis, isoelectrofocusing. Electrophoresis in DNA sequencing, Sanger- deoxynucleotide sequencing. Foot printing of DNA.

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, pulse field electrophoresis,

physical basis, equipment and applications. Electroblotting: western, southern, northern equipments and application.

9 hrs

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. Measurement of fluorescence and chemiluminiscence, use of fluorescence in binding studies. 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, IR spectroscopy, Raman IR spectroscopy.
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.
Mass spectroscopy: Principle, overview of MS- experiment, ionization modes, equipments in MS analysis (Identification of metabolites) MS of protein/ peptides. Interfacing MS with other methods; MS/MS, LC/MS, GC/MS, electrophoresis/MS. Uses of MS in Biochemistry: MS and heterogeneity in proteins, peptide mapping, post translation modification analysis, determination of disulfide bridges, analysis of DNA compounds.

15 hrs

Proteomics: Introduction, electrophoresis in proteomics, 2D SDS–PAGE, basic principle, instrumentation, analyses of cell proteins, free flow electrophoresis, blue native gel electrophoresis, Mass spectrometry in proteomics, tagging methods for MS proteomics, isotope coded affinity tagging, tagging for tandem MS. Microarrays, protein biochips. Post translational modifications in proteomics, proteolysis, glycosylation, oxidation, protein disulfides, phospho-proteins.

6 hrs

Bioinformatics: Definition and overview, sequence data, nucleotide and protein sequence, 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; Cambridge database, PDB, specialist structural databases. Programs for analysis and visualization of tertiary structure databases, RasMol/RasTop, protein explorer, Swiss-prot Pdb viewer, Homology modeling, modeling proteins from known homologous structures, and application in drug discovery.

7 hrs

References

1. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011)
2. Principle and techniques in Biochemistry and Molecular biology; Keith Wilson and John Walker (2005).
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, 2nd Edn. 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, Stipanuk Elseveir (2012).
8. Protein Bioinformatics; M. Michael Gromiha, Academic Press (1983).
9. Immuno Assay Hand Book; David Wild, Elsevier (2013).
10. Isoelectric Focusing; Theory, Methodology and Applications; P.G. Righetti , Elsevier (2013).
11. Fluorescence Microscopy; Anda Carnea and P. Michael Conn; Academic Press (2014).
12. Fluorescence Spectroscopy; Ludwig Brand and Michael Johnson, Academic Press (2008).

BCT – 203: Metabolism – I

4 Units (52 hrs)

Carbohydrate metabolism; Introduction, glycolytic pathway and regulation. Gluconeogenesis. pathway and regulation. Role of LDH. The TCA cycle and its regulation. Alternate pathways: HMP pathway, Enter – Doudoroff, Glucuronate and Glyoxylate pathway, Cori's cycle, Futile cycles and anaplerotic reactions. **12 hrs**

Glycogen and starch metabolism: degradation, synthesis and regulation, glycogen storage disorders. Pasteur effect, fermentative pathways in microorganisms.
Regulation of blood glucose level, hypoglycemia and hyperglycemia. Diabetes mellitus: introduction, biochemical and clinical changes associated with IDDM and NIDDM, control of hyper glycemia, diagnosis of Diabetes mellitus and GTT. Pentosuria, Hexose interconversion, fructose and lactose intolerance, fructosuria, galactosemia. Glycosylation of proteins

18 hrs

Lipid metabolism: Oxidation of fatty acids: even and odd numbered, unsaturated and branched chain fatty acids. Alternate routes for fatty acid oxidation. Degradation of triacylglycerols and phospholipids. Energetic of β-oxidation. Metabolism of ketone bodies; their formation, oxidation and clinical significance. Biosynthesis of triacylglycerols, phospholipids and sphingolipids. Sphingolipidodystrophies. Biosynthesis of steroids, related biosynthesis from isoprenoid units. Metabolism of prostaglandins and related compounds. Cholesterol biosynthesis, catabolism and regulation. Transport of cholesterol -LDL receptor pathway. Lipoproteinemias, fatty liver, hypercholesterolemia.
Chemical composition, biological functions and metabolic fate of VLDL, LDL and HDL.
Arachidonic acid metabolism-Leukotrienes

13 hrs

Photosynthesis: Introduction, chloroplast/thylakoid structure. Ultra structure and organization of chloroplast membranes, lipid composition of chloroplast membranes.
Photosynthetic reaction centre, photosynthetic apparatus, Hill reaction, light reaction, cyclic- and non-cyclic pho tophosphorylation. Dark reactions, CO_2 fixation into C_4-dicarboxylic acids. Bacterial photosynthesis, photorespiration, RUBISCO.

9 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, Eskin Elseveir (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).

BCT – 204: Membrane Biochemistry

4 units (52 hrs)

Introduction: Review of **s**tructure, nomenclature and properties of glycerolipids, sphingolipids, glycolipids and sterols. Properties of lipids in solution, hydrophobic and hydrophilic interactions, Polar lipids and their ability to form mono, bi-layers and micelles, Langmuir trough.
Cell and organelle membranes; Physical properties of bi-layers, Polymorphic phases and molecular shapes exhibited by lipids, use of differential scanning calorimetry (DSC) and ^{31}P NMR to study transition in phases. Effect of lipid composition and modification on viscosity and fluidity; role of cholesterol, cardiolpin, engineering membrane lipid composition. Models of membranes; Metamorphic mosaic model, Singer-Nicolson fluid mosaic model, Isolation and characterization of membrane lipids. Composition of plasma- and organelle membranes; transbilayer asymmetry; methods to determine membrane sidedness. Asymmetry of lipid distribution in bacterial, plant, and animal membranes, Lateral heterogeneity of membrane lipids; lipid domains, lipid rafts, caveoli, Non bilayer lipids and their role in membranes.
Physical organization of bilayers; human erythrocyte membrane as a prototype plasma membrane, role of cytoskeleton in organization of bilayers. *Liposomes;* preparation, properties and application in membrane biochemistry. **13 hrs**

Membrane proteins: Isolation and characterization of cell membranes. Detergent solubilization of membrane proteins. Purification and reconstitution of membrane proteins. Erythrocyte ghosts; proteins of RBC membrane and their interaction with cytoskeleton. Classification of membrane proteins based on membrane-protein interaction. Types of integral membrane protein, forces responsible for holding integral proteins in membranes, secondary structure of membrane spanning portions of integral membrane proteins; transmembrane α-helices and β-barrels, hydropathic plots. 3-D structures of typical integral membrane proteins: glycophorin, bacteriorhodopsin, photosynthetic reaction centre. Role of integral proteins in cell-cell interaction and adhesion; selectins, integrins, cadherins. Lipid-anchored membrane protein-acyl-prenyl- and GPI-anchors.

Techniques for determination of membrane protein topology: *Biophysical methods:* X-ray crystallography, Freeze-fracture electron microscopy, Spin labeled ESR, NMR. *Biochemical and molecular biological methods*: Membrane protein dynamics. Lateral and rotational diffusion of integral membrane proteins. Fluorescence photobleaching recovery (FRAP). Single particle tracking. Lipid-protein interactions. Atomic force microscopy.

10 hrs

Membrane transport: Relative permeability of pure phospholipid bilayer to various molecules. Diffusion across the plasma membrane. Partition coefficient and hydrophobicity. Energetics of moving non polar and polar molecules across lipid bilayer (PM). Experimental methods for study of membrane transport: Assay of membrane transport, use of liposomes to study single types of transporters. Mechanism for transport**:** Properties of passive diffusion**,** facilitated diffusion, active transport and co-transport. Electrically neutral and electrogenic transport, Kinetics and model of Glut-1 uniport ATP–driven pumps; classification, and working mechanism. ABC-transporters; MDR1, CFTR Channels and pores. Transport across organelle membranes. Ion channels; working and voltage gating, ionselectivity, electrochemical gradients, Nernst Equation, working of bacterial K-channels, aquaporinns, ionophores.

Bacterial transport systems; Lactose permease, Phospho transferase and sugar binding proteins.

7 hrs

Intracellular compartments: Proteins sorting; Membrane enclosed organelles of eukaryotic cells, evolutionary origin and topological relationships. Protein trafficking: Sorting signals. Mechanisms: Gated transport, transmembrane transport, vesicular transport. Signal sequences: Experimental evidence, Genetic experiment to demonstrate protein translocation.

Transport of molecules between nucleus and cytosol. Nuclear pore, nuclear localization signals, nuclear transport receptors, nuclear export: Ras-GTPases- directionality. Regulation of nuclear import and export.

Transport of protein into mitochondria and chloroplast, signal sequence, experimental setup to study protein translocators, working of TOM & TIM complexes. Energy requirement in protein import. Signal sequence for thylakoid membranes, peroxisomes. Endoplasmic reticulum, structural and functional diversity of endoplasmic reticulum, isolation of rough ER and signal sequence for protein import.

Signal Hypothesis: Signal Sequence, SRP-receptors for protein import to ER. Organization of translocation pore, Sec61 complex.

8 hrs

Topology of membrane protein: Protein translocation, cotranslational, post translational translocation. Start transfer and stop transfer signals for single pass transmembrane protein and multipass transmembrane proteins. ER retention signals, Glycosylation in ER. N-linked oligosaccharide, Dolichol-linked oligosaccharides. Folding of proteins in ER, role of chaperons – Calnexin and Calreticulin. N-linked oligosaccharides as timers for protein turnover, ubiquitination and protein degradation (improperly folded proteins), GPI-anchored proteins.

5 hrs

Biogenesis of lipid bilayers: Intracellular vesicular trafficking: Maintenance of compartmental diversity, pathways of endocytosis and secretory. Vesicles: types, study of cell free system, genetic approach, use of GFP. Clathrin coated- Assembly and disassembly, Structure and function. significance. Coatemer coated-Assembly and disassembly, Structure and function. Retromer assembly on endosomal membrane. Coat assembly control by monomeric GTPases. Role of Rab proteins in vesicular targeting. SNARE proteins and their role in vesicular transport and membrane fusion. Experimental proof for SNARE requirement in vesicular fusion. Entry of enveloped viruses into cell. Coatemer coated vesicles: COP-II-coated transport vesicles, transport of cargo from ER to Golgi, homotypic membrane fusion. Retrieval pathway to ER.
Compartments of Golgi: processing of oligosaccharide chain in Golgi, N-linked, proteoglycan assembly in Golgi. Transport through *trans* Golgi network to lysosomes. Mannose-6-phosphate receptors. Signal patch for mannose-6-phosphate lysosomal storage disease. Endocytosis: Phagocytosis, Pinocytosis- vesicles, receptor mediated endocytosis. Retrieval of proteins in endosomes, multivesicular bodies sequestration of endogenous proteins.

9 hrs

References

1. Biochemistry 5th Edn. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer.
2. Harper's Illustrated Biochemistry; 27th Edn. Robert K. Murray, Daryl K. Granner, Victor W. Rodwell , The McGraw-Hill (2006).
3. Lipid Biochemistry; 5th Edn. Michael I. Gurr, John L. Harwood and Keith N. Frayn, Blackwell Science (2002).
4. Biochemistry of Lipids, Lipoproteins and Membranes; 5th Edn. Dennis E. Vance and Jean E. Vance, Elsevier (2008).
5. Membrane Protein Purification and Crystallization; Carola Hunte, Gebhard von Jagow and Hermann Schagger, Academic Press (2011).
6. Membrane Proteins,; Douglas Rees, Academic Press (2003).
7. Introduction to Biological Membranes; William Stillwell, Elsevier (2013).
8. Molecular Biology of the Cell, Alberts et al., Garland Publications (2012).
9. Molecular Biology of the Cell; 6th Edn. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts and Peter Walter; Garland Science (2014).
10. Molecular Cell Biology; Lodish et al., 7th Edn. W.H. Freeman and Co. (2012).

BCSCT – 205: Microbiology

3 units (39 hrs)

Bacteriology: Classification of Bacteria – Conventional and molecular methods; Identification and classification of microorganisms; *Eubacteria, Archaebacteria, Cynobacteria,* Bergy's classification of bacteria. Brief study of important groups of bacteria: Coliform, spore formers, photosynthetic bacteria, lactic acid producing bacteria, *actinomycetes, ricketisiae, mycoplasms*. **5 hrs**

Eukaryotic Microorganisms: Fungi- classification, cultivation and morphology of yeasts and molds. Control of fungal growth. Mycotoxins and their actions. Brief study of algae and protozoa. Media for culture of algae and protozoa. **4 hrs**

Staining techniques- Gram, Acid fast & flagellar. Detailed study of bacterial cell structures- genetic elements, ribosomes, membranes, cell envelope, capsule, flagella, pili and endospores. Mechanism of bacterial motility. 3 **hrs**

Pure culture techniques: Principles of microbial nutrition: Nutritional requirements, different kinds of media, factors affecting growth. Enrichment culture techniques for isolation of chemoautotrophs, chemoheterotrophs and photosynthetic microorganisms. Modes of reproduction, Biosynthesis of cell wall components, enumeration, growth curve, generation time, synchronous growth, Chemostat. Adaptation to stationary phase, heat and cold shock, osmolarity and salinity, oxidative stress. 6 **hrs**

Control of Microbial Growth:, Principles of Microbial growth, Sterilization methods and sterility testing. Physical and chemical methods of controlling bacterial growth. Antibiotic-targets and action. **3 hrs**

Food Microbiology: Food spoilage, food preservation, fermented foods, exotoxins produced by bacteria. **3 hrs**

Dairy Microbiology: Contamination of milk by micro-organisms. Bacterial count, reactions occurring in milk, Pasteurization and sterilization. Fermented milk products, cheese. **4 hrs**

Medical Microbiology; Normal mouth, nose, and throat flora, Mechanisms and control of bacterial pathogens. Antiseptic and disinfectant action; Antibiotic assay; Determination of minimum inhibitory concentration (MIC), endotoxins. **4 hrs**

Virology: Classification and General Properties and structure of plant, animal and bacterial viruses.

Bacteriophages; one step growth experiment, single burst and premature lysis experiments, productive cycles of λ and ϕx-174 viruses, lysogeny – P1, P2, P22 and Mu1 phages, RNA phages, isolation and cultivation of bacterial viruses.

Plant viruses- transmission, effect on plants, common diseases, TMV. Slow viruses and DI viruses- discovery and importance.

Animal viruses- productive cycle of DNA viruses- parvo, adeno and SV40. RNA viruses- reo, rhabdo, picorna, polio, Influenza Retrovirus (RSV and HIV)

Cultivation and enumeration of viruses; cultivation in cell culture, chick embryo and animal inoculation. Persistent chronic and acute viral infections. Inhibition and inactivation of viruses by physical and chemical agents.
Interferon- types, nomenclature and classification, induction, antiviral effect, antiviral proteins-ds RNA dependent and independent pathways. **7 hrs**

References:

1. Microbial physiology, 2nd Edn. I.W. Dawes and I.W. Sutherland (1991) Blackwell Scientific.
2. Microbial physiology, 4th Edn. Albert G. Moat, John W. Foster and Michael P. Spector, Wiley-Liss (2002).
3. Modern Food Microbiology; James M.Jay (1996) CBS Publishers.
4. A Modern Introduction to Food Microbiology; Board, R.G. (Ed.) (1983) Blackwell Scientific Publications.
5. Biology of Microorganisms, Brock Prentice Hall (1996).
6. Industrial Microbiology; Miller and Litsky (Eds.) (1976) McGraw Hill Publishers.
7. Microbiology; Lansing M. Prescot, Hartley and Klein, 5th Edn. McGraw Hill (2002).
8. Microbiology; Essentials and Applications, Larry Mckane and J.Kandel (19) McGraw Hill publishers.
9. Applied Microbial Physiology: A practical approach Rhodes and Stanbury (1997) IRL Press.
10. Microbes in Action, A Laboratory Manual of Microbiology Seley et al., (19) W.H. Freeman.
11. Basic and Practical Microbiology, Ronald L. Atlas (1986) McMillan Publication Co.
12. General Microbiology, Stainer et al., 4th Edn. McMillan (1975).
13. Microbiology, Pelczer, Reid and Kreig Tata McGraw Hill (1996).
14. Biology of Microorganisms, Brock Prentice Hall (1996).

BCP – 206: Biochemical and Immunochemical Techniques (4 Credits)

1. Ascending descending and circular paper chromatography of amino acids / carbohydrates
2. Two-dimensional chromatography of amino acid / carbohydrates.
3. Thin layer chromatography of carbohydrates / amino acids.
4. Gel–permeation chromatography of pigments/proteins.
5. Separation of proteins by non-denaturing PAGE.
6. Determination of molecular weight of Proteins by SDS–PAGE
7. Separation of isoenzymes by isoelectric focusing
8. Ion exchange chromatography of nucleic acids / proteins.
9. Demonstration of Ag-Ab interaction: Radial immuno-diffusion and ODD.
10. Demonstration of direct agglutination reaction using human blood group antigens.
11. Demonstration of indirect agglutination reaction-latex agglutination.
12. Bacterial agglutination (WIDAL)
13. Antibody titration – ELISA; Direct, Indirect, sandwich, and micro ELISA.
14. Purification of antibodies; conventional (isolation of IgY from Egg yolk).
15. Rocket electrophoresis.
16. Western blotting of proteins and Immuno-detection.

References

1. Methods in Immunology and Immunochemistry; Curtis Williams, Academic Press (1971).
2. Immuno Assay Hand Book; David Wild, Elsevier (2013).
3. Basic Methods for the Biochemical Lab; Martin Holtzhauer, Springer, (2007).
4. Principles and Techniques of Biochemistry and Molecular Biology 7^{th} Edn. Keith Wilson and John Walker, Cambridge University Press, (2010).
5. Laboratory Techniques in Biochemistry and Molecular Biology, Work and Work Vol. I & II, North Holland, (1969).
6. Principle and Techniques of Practical Biochemistry; Keith Wilson and John M. Walker, Cambridge University Press (2000).
7. Biochemistry LabFax, Ed. J.A.A. Chambers and D. Rickwood,, Blackwell Science, (1993),
8. Protein Purification Applications, S.L.V. Harris and Angal IRL Press, (1990)
9. Laboratory Techniques in Biochemistry and Molecular Biology, Work and Work Vol. I & II, North Holland, (1969).

BCP – 207: Enzymology (4 Credits)

1. Determination of total activity of pea esterase.
2. Determination of K_M 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 I_{50} of pea esterase using organophosphate inhibitor.
9. Determination of total activity of salivary α-amylase /β-amylase (sweet potato 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 I_{50} of alkaline phosphatase.
14. Determination of inhibitor constant, Ki of alkaline phosphatase.
15. Determination of optimum temperature and activation energy of urease (horsegram).

References

1. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry: Trevor Palmer, Horwood, (2001).
2. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis: Robert A. Copeland, by Wiley-VCH Inc. (2000).

3. *Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis*: Robert A. Copeland , John Wiley & Sons (2000).
4. Enzyme Kinetics: *A Modern Approach*: Alejandro G. Marangoni, John Wiley & Sons (2002)
5. Enzyme Kinetics: *Principles and Methods:* Hans Bisswanger, Wiley–VCH (2002).
6. Fundamentals of Enzyme Kinetics: 4th ed. Athel Cornish-Bowden, Wiley-Blackwell (2012).
7. *Fundamentals of Enzyme Kinetics*: Athel Cornish-Bowden, Portland Press (2004)
8. *Practical Enzymology:* Hans Bisswanger, Wiley–VCH (2004)
9. Practical Enzymology, Second Revised Edtion [PDF] [StormRG]: Hans Bisswanger, Wiley – Blackwell; 2 edition (2011)

Third Semester M. Sc. Biochemistry

BCT – 301: Molecular Biology – I

4 units (52 hrs)

Introduction: Historical account of DNA discovery. Relationship between genes and proteins, overview of flow of genetic information; central dogma of molecular biology. Nature of genetic material, experiments confirming DNA as genetic material. Review of physical chemistry of DNA. RNA as genetic material. Variation in size and shape of genomes; ultracentrifugaion 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, measurement of expressed genes.
Clusters and repeats; tandem repeats, mini- micro- satellites and interspersed genome-wide repeats and their significance. Pseudo genes and transposable elements. Globin gene clusters, gene duplication and gene evolution, biases in mutations, gene conversion and codon usage.
Topological problems; Topo-isomerases, gyrases and helicases- mechanism and classification. Multi copy and single copy replicons, Linear and circular replicons, unidirectional and bi-directional replication of DNA. Experimental methods to map origin of replication. Semi-conservative and semi-discontinuous replication; experimental demonstration. **11 hrs**

Prokaryotic DNA Replication: Replicon, single and multi copy replicons, linear and circular replicons, unidirectional and bidirectional replication, experimental methods, mapping origin of replication, semi-conservative and semi-discontinuous replication; experimental demonstrations. Topological problems in DNA replication; topoisomerases, helicase and gyrase. Mechanism and classification of topoisomerases, assay of topoisomerases. 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, sequesteration of origins after replication, role of helicase, assay of helicase.
Enzymology of DNA replication; DNA polymerases, chemistry of nucleotide polymerization and in vitro assay. 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. Hand-palm structure of DNA polymerases. Processivity and fidelity of replication. Bacterial replication and its connection to cell cycle

Eukaryotic DNA replication; Replicative and repair enzymes of eukaryotes. Initiation, elongation by eukaryotic DNA polymerases. 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. **12 hrs**

Extra chromosomal replication: Replication of phage DNA ϕX174, T7, SV-40, rolling circle model of replication. Linear DNA-ends, terminal proteins, replication of plasmid DNA.

Replication of RNA viruses: ss +RNA viruses; Picarna (Polio) and carona viruse, ss-RNA viruses; rhabdo virus (VSV), orthomixovirus (influenza virus). dsRNA- reovirus (Rota virus), Structure and mechanism of RDR pol. Retroviruses; Structure and mechanism of reverse transcriptase and integrase (HIV), replication of tumor virus (RSV). Replication of Qβ virus. **7 hrs**

DNA repair: experimental demonstration of repair in prokaryotes, damaging agents and damage recognition, direct repair, Miss-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 **4 hrs**

Transcription in prokaryotes: 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. **5 hrs**

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 pol-II). 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.

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 splicing RNase. Group-I introns, demonstration of exon ligation, Group-II introns.
Post transcriptional modification of mRNA: Structure of cap, purification of caps, capping substrate. Cap structure of Reovirus, 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. **13 hrs**

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. Principles of Developmental Genetics; S.A. Moody, Academic Press (2007).
12. Developmental Biology; S. P. Gilbert, 8th Edn, Sinauer Associates Inc.,(2006)
13. Molecular biology and Biotechnology; 4th Edn., J.M. Walker and R. Rapley, RSC (2000).
14. Molecular Biology of Gene; Watson, J.D. et al., 5th Edn. Pearson Education; (2004).
15. Principles of Virology; S.J. Flint et al., ASM Press (2000).
16. Biochemistry and Molecular Biology; 5th Edn. D.Papachristodoulou, A. Snape, W.H. Elliott, and D. C. Elliott Oxford University Press (2014)
17. Chromatin structure and Gene Expression; 2nd Edn. Sarah Elgin, Jerry Workman, Oxford University Press (2000)
18. Molecular Cell Biology; Harvey Lodish 5th Edn. (2010)
19. Biochemistry 5th Edn. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer (2011).
20. Genome Stability: DNA Repair and Recombination; James Haber, Garland Science (2013)
21. Retroviruses; Coffin JM, Hughes SH, Varmus HE, editors; CSH Press, (1997)
22. Viruses: Biology, Applications, and Control; David Harper, Garland Science (2011).

BCT – 302: Molecular Physiology

4 Units (52 hrs)

Nerve signaling: Acetylcholine receptor (AchR) channel, origin and mechanism of actions of neurotransmitters (Acetylcholine, catecholamine, serotonin; amino acids (glutamate, aspartate, GABA, and glycine) and neuropeptides (somatostatin/enkephalins).
Trafficking proteins of synaptic vesicles, vesicle cycle – exo – and endocytosis of synaptic vesicles.
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. Biochemical basis of neurological diseases. Natural, genetic and environmental factors affecting the development of CNS, Co – ordination between nervous and endocrine systems. **13 hrs**

Endocrine signaling: Signal transduction**,** extra – cellular signaling; hormones as signal molecules – peptide, amino acid derivatives, steroid, ecosanoids.
Signal transduction pathways of – 1) G – protein linked (epinephrine, serotonin, glucagons), 2) Ion–channel (ACh), 3) Tyrosine kinase {(RTK), [EGF, IGF, insulin]}, and 4) Intrinsic enzyme / cytokine, receptors.
Biochemistry of vision: Structure of an eye, lens and retina, perception of light, rods and cones, rhodopsin, primary events in visual excitation, cGMP and transduction in generation of nerve impulse, colour vision
Intracellular signaling proteins: {adaptors, activators, bifurcators, integrators, effectors, etc.}. Second messengers; and their regularization: cAMP, CREB, cGMP, phosphoinositides, arachidonic acid, Ca^{2+}, and NO. Signal amplification cascades; Cascades downstream of RTK; Erk – fos – jun – cyclin – D, MAPK – Ras – Raf – Sos, specificity of protein kinases.
Effectors on intercellular signaling: Adenylate cyclase, Phospholipase- C, Nitric oxide synthase, guanylate cyclase and their activation, negative modulation.

Nuclear signaling: Steroid, thyroid, Vitamin-D and retinoic acid receptors and transcriptional activation. Transcriptional activation by phosphorylation cascade; CREB. **18 hrs**

Cell Cycle: Cell cycle (entry of cell from G_2 to M – phase) Role of M – Cdk, MPF. Promotion of G1/S by growth factors, cell cycle arrest at G_1, role of Rb proteins in cell cycle arrest. Regulation of M- phase (role of mitogen, survival factor and TGF- β). Role of ubiquitin.
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.
Stem Cells: Embryonic and adult stem cells; unique properties, and potential applications.

Apoptosis: Discovery, morphological changes, mitochondrial regulation. Direct signal transduction (TNF pathway, Fas pathway, caspases, execution and removal of dead cells). Distinguishing apoptotic cells from necrotic cells. Role of HeLa cells, Hyperactive apoptosis and treatments.

Cancer: Introduction, Signs and symptoms, causes pathophysiology, diagnosis, prevention and management. Signaling cascades in cancer (MAP kinases, Ras pathways, JAK-STAT and TGF-β pathways). Etiology of breast, colon and prostrate cancer. **19 hrs**

Signaling in Plants: Outline of plant hormones and pheromones signaling. **2 hrs**

References

1. Signal transduction and human disease; Toren Finkel, and J. Silvio Gutkind, John Wiley & Sons, Inc. (2003)
2. Greenspan's Basic and Clinical Endocrinology; 9th Edn. David Gardner and Dolores Shoback Lange Clinical Medicine (2012).
3. Biochemistry of Signal Transduction and Regulation; Gerhard Krauss, Wiley-VCH (2003).
4. Elements of Molecular Neurobiology; 3rd Edn. C. U. M. Smith, John Wiley & Sons Ltd, (2002).
5. Basic Neurochemistry; George Siegel et al., (1999) Wippincott, Williams and Wilkins.
6. Neuroscience; 2nd edn. Purves, Dale; et al., Sinauer Associates, Inc. (2001).
7. G-Proteins coupled Receptors; P. Michael Conn Academic Press (2013).
8. Molecular Biology of the Cell; 6th Edn. Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter; Garland Science (2014).
9. Molecular Cell Biology; Lodish et al., 7th Edn. W.H. Freeman and Co. (2012).
10. Cell Signaling; Wendell Lim, Bruce Mayer, Tony Pawson; Garland Science (2014).
11. Cell Biology; A short course; Stephen R. Bolsover et al., John Wiley & Sons, Inc. (2004)
12. Electrochemical methods for neuroscience; Michael AC, Borland LM, editors. Boca Raton (FL): CRC Press (2007).
13. Signal Transduction; Lewis Cantley, CSHL Press (2014).
14. When Cells Die; A Comprehensive Evaluation of Apoptosis And Programmed Cell Death; Richard, A. Lockshin, and Zahra Zakeri, Wiley Liss (2004).
15. Neuroscience; 2nd edn. Purves, Dale; et al., Sinauer Associates, Inc.; (2001).
16. Biochemistry of Signal Transduction and Regulation; 3rd Edn. Gerhard Krauss, Wiley-VCH, (2003).
17. The Biology of Cancer; Robert A. Weinberg; Garland Science (2013).

BCOET – 303.1: Metabolism – II

4 units (52 hrs)

Bioenergetics: 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. **2 hrs**

Biological oxidation: 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. **4 hrs**

Oxidative phosphorylation: Mechanism of proton pumping. Proton motive force and the Mitchell hypothesis. FoF1-ATPase- structure and mechanism, O^{18} 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, mitochondrial specific transport systems and energy charge. 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**

Nitrogen Cycle: Introduction, biological and non-biological nitrogen fixation, *nif* genes, regulation and utilization of nitrate and nitrite, regulation of nitrate reductase. Assimilation of ammonia, formation of amino acid amides by glutamine synthetase and its regulation. **4 hrs**

Nucleotide Metabolism: Biosynthesis of purine and pyrimidine nucleotides and their inter conversion, regulation of biosynthesis. Other pathways of purine nucleotide formation. Biosynthesis of deoxyribonucleotides and coenzymes nucleotides. Chemical inhibition of the biosynthesis of nucleic acid precursors. Degradation of purine and pyrimidines, and disorders associated with their metabolism; gout, Lesch-Nyhan syndrome, oroticaciduria, and xanthinuria. **7 hrs**

Amino acid Metabolism: General metabolic reaction of amino acids– transamination, pseudotransamnation, 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). **7 hrs**

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, acetoaetate and/or acetyl CoA (phenylalanine and tyrosine). Inherited disorders associated with glycine, aromatic, branched chain, basic and sulfur containing amino acid metabolism. **9 hrs**

Biosynthesis of the 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 leuvine), 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. **9 hrs**

Heme Metabolism: Biosynthesis and degradation of porphyrin and their regulation, porphyrias, jaundice and Hemoglobinopathies. **3 hrs**

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).

BCOET – 303.2: PLANT PHYSIOLOGY

4 units (52hrs)

Plant cell: Structure, anatomy and molecular components; Cytoskeleton– an overview. Plant cell cycle and its regulation. Energy production in plant cells and its control. Metabolism of sucrose and starch. **6 hrs**

Plant cell membranes and membrane transport: Introduction to plant cell membranes and membrane constituents. Organization of transport systems across plant membranes; Different types of pumps in plant cell and organellar membranes; Classification and importance of H+–ATPases. Ion channels-properties and significance; Aquaporins and water transport. **10 hrs**

Plant growth regulators and Tissue Culture: Biosynthesis and functional significance of auxins, cytokinins, gibberellins, abscisic acid, ethylene, brassinosteroids, polyamines, jasmonic acid and salicylic acid. An overview of plant tissue culture – Totipotency of plant cell; preparation and surface sterilization of explants; composition and constituents of regular media, conditions for culture maintenance. Influence of plant growth regulators on *in vitro* plant regeneration, callogenesis**.** **12 hrs**

Plant secondary metabolites: Introduction; Classification – structural, functional and biosynthesis. An overview of primary metabolism contribution to secondary metabolite biosynthesis; important routes (pathways) of biosynthesis- phenyl propanoid pathway; Mevalonate pathway; Acetate-mevalonate pathway. An overview of plant senescence. Strategies and approaches for the over production of plant secondary metabolites – plant cell suspension cultures, hairy root cultures, metabolic engineering, heterologous gene expression and combinatorial biochemistry. **12 hrs**

Plant responses to biotic and abiotic stresses: Introduction; Plant pathogens and diseases; plant defense systems-hypersensitive response; systemic acquired resistance; induced systemic resistance; Plant abiotic stress responses-Salt stress, drought and heavy metal stress responses; osmotic adjustment and significance of osmotic agents such as proline, sugar alcohols and quaternary ammonium compounds; An overview of oxidative stress and oxidative damage. Anti-oxidant enzymes and stress tolerance. Plant biotic stress response – pathogen and insects.

12 hrs

References

1. Lehninger- Principles of Biochemistry; David L. Nelson and Michael M. Cox, 6th Edition, W. H. Freeman (2013).
2. Biochemistry; Donald Voet, Judith G. Voet, 4th Edition, John Wiley and sons (2010).
3. Biochemistry, Lubert Stryer et al., W.H. Freeman & Company, New York, (2003).
4. Principles of Biochemistry, Horton, Moran, Ochs, Rawn, Scrimgeour Prentice Hall, (2002)
5. Plant Biochemistry, P.M. Dey & J.B. Harborne(2000) Hart Court Asia Pte Ltd.
6. Introduction to plant Biochemistry. Goodwin and Mercer, CBS Publisher (2000).
7. Biochemistry and Molecular Biology of Plants. Buchanan, Greussem and Jones, AAPS (2000).
8. Plant Cell Tissue and organ Culture: Fundamental Methods, O.L. Gamborg & G.C. Phillips Narosa Publishers, New Delhi (1995)
9. Plant Biochemistry; P. M. Dey and J. B. Harborne, Academic Press (1997).
10. Plant Biochemistry and Molecular Biology; Peter J. Lea, Richard C. Leegood, 2nd Edition, Wiley (1998).
11. Plant Biochemistry; Hans-Walter Heldt and Birgit Piechulla, Academic Press (2004).

BCP – 305: Clinical Biochemistry (4 Credits)

Analysis of Blood and Urine for diagnostic investigations

1. Estimation of glucose by Folin Wu method.
2. Estimation of glucose by Dubosky's 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 17-ketosteroid by Zimmerman's method.
16. Estimation of urine Bilirubin.

References

1. Practical Clinical Biochemistry, ed. Harold Varley, 4th edn. CBS Publishers (1988).
2. Practical Clinical Biochemistry: Methods and Interpretation, ed. Ranjna Chawla, Jaypee Brothers Medical Publishers (1996).
3. Practical and Clinical Biochemistry for Medical Students, ed. T.N. Pattabhiraman, Gajanna Publishers (1994).
4. Hawk's Physiological Chemistry, ed. Oser, 14th Edn.(1976), Tata-McGrawHill.
5. Biochemistry, ed. Plummer Tata-McGraw Hill, (1971).

BCP – 306: Molecular Biology (4 credits)

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.
3. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of plasmid DNA from bacteria.
4. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of total RNA, 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.

References

1. Molecular Biology Techniques; Sue Carson, Heather Miller and D. Scott Witherow, Academic Press (2011).
2. Principles and Techniques of Biochemistry and Molecular Biology; 7th Edn. Keith Wilson and John Walker (2012).
3. Principles of Gene Manipulations; 6th Edn. S.B. Primrose, R.M. Twyman, and R.W. Old, Blackwell Science (2012).
4. Gene Cloning and DNA analysis- An Introduction; T. A. Brown, 5th Edition, Wiley-Blackwell (2006).
5. Laboratory methods in Enzymology; Part-A; Jon Lorsch, Academic Press (2014).
6. Gene Cloning Laboratory Manual 4th Edn. Michael R. Green and Joseph Sambrook, CSHL Press (2014).
7. Current Protocols in Molecular Biology; S Gallaghar, Wiley Interscience (2008).

Fourth Semester M. Sc. Biochemistry

BCT – 401: Molecular Biology – II

4 units (52 hrs)

Gene Expression in Prokaryotes: Definition of regulon, operon, cis and trans acting elements. Bacterial trascription control; the lac operon, induction and diauxy. Discovery and structure of lac operon. Positive control 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 PL 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. **12 hrs**

Gene Expression in Eukaryotes: Stages/levels of regulation of gene expression in eukaryotes; Chromatin structure and its effect on transcription . Organization of chromatin- 30 nm fiber, higher order chromatin folding. Effect of histones on transcription activation. 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 P_{55} and Gcn-5 HATs. Histone deacetylases; experimental demonstration of HDACs in repressor complexes.
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.
Mapping and quantifying transcripts; Northern blots; S1 mapping of 5' and 3' ends of transcripts. Primer extension, Runoff transcription and G-less cassette transcription, measuring *in-vivo* transcription rate- nuclear run on transcription. Quantification of gene expression by measuring protein product. **10 hrs**

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, working of imprinting control region (ICR). Transcription factories, detection. Co-activators and mediators; discovery of mediators- mediators factors; activation of CRE-linked gene model for nuclear receptor activation. Regulation of transcription factors;

modification of activation by ubiquitination, sumoylation and acetylation. Signal transduction pathways; Ras, Raf, JAK stat pathway.
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. Stimulation of translation by miRNAs. Translation repression; processing bodies.
12 hrs

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. **7 hrs**

Ribosomes: Prokaryotic ribosomes; molecular components, *in vivo* assembly, dissociation of subunits, and polysomes. Eukaryotic components and their assembly, organelle ribosomes.
3 hrs

Translation: Initiation of protein synthesis in prokaryotes, Shine-Dalgarno sequence, formation of 30 S and 70 S 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. Amino acyl-tRNA synthetases, formation of ternary complex among amino-acyl tRNA, EF-T, and GTP, three site model of ribosome, peptide bond formation, G-protein and translation, stop codon supression, release factors, aberrant termination, non-stop mRNAs, termination of transcription, termination codon, no-go-decay of mRNA. Inhibitors of prokaryotic and eukaryotic translation. Post-translational modifications of proteins. Mechanism of translational control.
Genetic code; breaking the code, experimental results leading to deciphering genetic code, coding properties of mRNA, Co-linearity of genes and proteins, Coding properties of tRNA, triplet binding assay, use of synthetic oligo nucleotides (works of Khorana and Neirenberg), base pairing between codon and ani-codon, Wobble base pairing. Properties of genetic code, deviation from universal genetic code. **8 hrs**

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 XI; J.E. Krebs, E.S. Goldstein, and S.T. Kilpatrick, Jones and Barlett Publishers (2012).
4. Molecular Biology; Robert F. Weaver, Mc Graw-Hill (2012).

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; 7th Edn. Bruce Alberts et al., (2008), Garland Publications
9. Molecular Biology; David Freifelder, J. (1997) Narosa publishers.
10. Nuclear Organization; Chromatin Structure and Gene Expression, Roen Van Driel and Arie P. 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. Principles of Biochemistry; Lehninger et al., [Eds.] 2nd Edn. Worth Publishers (1997).
15. Human Molecular Genetics; Peter Sudbery, (2002) Printice Hall.
16. The Cell- A Molecular Approach; Geoffery M. Cooper, Robert E. Hausman, 6th Edition, Sinauer Associates Inc. Publishers (2013).
17. Long Range Control of gene Expression; Veronica van Heyningen and Robert Hill, Academic Press (2008).

BCT – 402: Biochemical Genetics

4 units (55 hrs)

Introduction: Nature of genetic material. Chromosomes and genes. Mutation: types of mutation, mutagens, mechanism of mutation, induction and isolation of mutants and their role in genetic studies. **5 hrs**

Classical Genetics: Review of classical genetics; work on *Pisum sativum, Drosophila Melanogaster, Neurospora Crassa 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 chromo;somes, XX,XY, mechanism of sex determination. **10 hrs**

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, estimation of Heritability Index. **8 hrs**

Human Genetics: Biochemical events occurring during mitosis and meiosis. Structure of chromatin; nucleosomes and higher orders of organization. Chromosome banding, Chromosome mapping based on recombination frequency data. Transposons. Overview of human genome project, mapping of human genes; techniques used, assignment of important genes. Transposition in human chromosomes. Chromosomal abnormalities. **13 hrs**

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. **8 hrs**

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. **8 hrs**

References

1. Genetics, Strick Berger, M.W. (1990) 3rd edn. McMillan.
2. Human Molecular Genetics; Peter Sudbery, (2002) Printice Hall.
3. Introduction to Modern Virology, Primrose and Dimmock (1988), Blackwell Sc.
4. 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. Hausman Sinauer 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: Biotechnology

4 credits (52 hrs)

Introduction; Introduction and over view of cloning procedures. Isolation of nucleic acids, characterization and purification of plasmid, bacteriophage genomic DNA for cloning purpose. **3 hrs**

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

Cloning Vectors: Basic properties of plasmids, desirable properties of vectors, plasmids as vectors. Directional cloning in plasmid vectors, blunt end cloning in to plasmids. Preparation and transformation of competent *E.coli.* electroporation, Screening colonies using X-gal and IPTG (□-complementation), screening by hybridization. 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, expression vectors for cloning and expression in bacteria, yeast and mammalian cells. Super vectors; characteristic features and utility of BAC and YAC vectors. **9 hrs**

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

PCR: Discovery, principle and procedure, varients of PCR- RT-PCR, long PCR, differential PCR, and inverse PCR. Application of PCR; Rapid amplification of cDNA ends (5'and 3' RACE), Cloning PCR products, PCR in screening clones, colony PCR, Diagnositc application of PCR. **6 hrs**

Sequencing and mutagenesis: 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. **4 hrs**

Gene transfer to animals 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. **6 hrs**

Gene transfer to plants: plant cell culture and proptoplast, callus and their manipulations. *Agarobacterium* mediated transformation, Ti plasmid, mechanism of T-DNA transfer, Function of T-DNA genes, Ti-plasmid derivatives as plant vectors (disarmed T-DNA), cointegrate and binary vectors, high capacity binary vectors, selectable markers for plants, control of transgene expression in plants. Direct DNA transfer to plants; protoplast transformation, particle bombardment, *in-planta* and chloroplast transformation. Plant expression vectors; CaMV and TMV vectors. **6 hrs**

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: Immunology and Toxicology

4 units (52 hrs)

Infection: Types of infection and nature of infective agents. Nonspecific host defense mechanisms. Anatomical barriers; lysozyme and other antimicrobial agents. Phagocytosis and phagocytic cells, neutrophils, monocytes and macrophages. **4 hrs**

Compliment system: Introduction, alternate and classical pathway, regulation **4hrs**

Immunity: States of immunity; innate and acquired immunity, naturally and artificial acquired passive and active immunity. Immunization practices, use of toxoids, killed and attenuated organisms. Surface components and newer vaccines, production of vaccines. **4 hrs**

Immunoglobulins: Structure and functions of immnoglobulins Types; isotypes and idiotypes, isoantibodies. Methods of raising antibodies. Monoclonal antibodies, production and purification. **5 hrs**

The Immune System: Recognition of self and non self, the major histocompatibility antigens, H-2 and HLA antigens, Antigenecity; humoral and cell mediated immunity. T and B lymphocytes; origin, differentiation, characteristics and functions, nature of surface receptors, antigen processing and presentation. T cell and B cell interaction. Cytokines, monokines, lymphokiness and their functions. **8 hrs**

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

Clinical Immunology: Immune disorders; hyper sensitivity, autoimmune and immunodeficiency diseases. Tissue transplantation; auto – iso -, allo-, and xenografts, tissue matching, transplantations rejection, mechanism and control, tumor immunology. **5 hrs**

Immuno assay methods: Antigen – antigen interaction – affinity and avidity, determination of affinity and avidity constants. Principle, procedure and applications of Immunoprecipitation,

neutralization, agglutination, compliment fixation, immunodiffusion, immunofluorescence, RIA, ELISA, micro ELISA Techniques. **4 hrs**

Toxicology: Toxicological chemistry, factors influencing toxicity; Dose response relationship – 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. Non metal–oxygen and ozone. **13 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).

BCP – 405: Genetic Engineering and Protein Chemistry (4 Credits)

Genetic Engineering

1. Preparation of Competent cells.
2. Transformation of DNA by $CaCl_2$ method (recombinant vectors – plasmids / phages).
3. Isolation and characterization of gene fragments for cloning
4. Restriction digestion of isolated plasmid DNA.
5. Expression of GFP in *E. coli*.
6. DNA Amplification (PCR).
7. Synthesis of cDNA.
8. Southern Blotting and Northern Blotting; Hybridization of DNA and RNA and detection by specific probes (non-radioactive).
9. Characterization of clones by restriction digestion and agarose electrophoresis.

10. Expression, Isolation and purification of recombinant proteins.

Protein Chemistry

1. Extraction and isolation of enzymes (phosphatases / esterases / amylases) from Insect / Microbial / Plant sources.
2. Fractionation and purification by conventional protein purification techniques (PAGE showed be carried out at each step).
3. Ammonium sulfate, acetone and pH precipitation
4. Ion exchange chromatography.
5. Gel filtration.
6. Kinetic characterization of the enzyme

References

1. Nucleic Acid Blotting; D C Darling, P M Bricknell; Garland Science; (1994)
2. Principles and Techniques of Biochemistry and Molecular Biology; 7th Edn. Keith Wilson and John Walker (2012).
3. Principles of Gene Manipulations; 6th Edn. S.B. Primrose, R.M. Twyman, and R.W. Old, Blackwell Science (2012).
4. Gene Cloning and DNA analysis- An Introduction; T. A. Brown, 5th Edition, Wiley-Blackwell (2006).
5. Laboratory methods in Enzymology; Part-A; Jon Lorsch, Academic Press (2014).
6. Gene Cloning Laboratory Manual 4th Edn. Michael R. Green and Joseph Sambrook, CSHL Press (2014).
7. Current Protocols in Molecular Biology; S Gallaghar, Wiley Interscience (2008).

BCP – 406: Project Work (4 Credits)

Open elective for Non-Biochemistry PG students

BCOET – 304.1: Biochemistry of Common Disorders

4 credits (52 hrs)

Human Physiology: Introduction and brief description of cells, tissues and organs, their functions; Body fluids and their composition. Introduction to molecules as building blocks. Definition and differentiation of disease and disorder, types and causes. Relation between food, environment and illness. Analysis of various biochemical parameters in body fluids and specific tissues during disorders, diseases and forensics. **14 hrs**

Diagnostic Techniques: Collection and storage of biological samples for clinical use. Commonly used tests for diagnosis of various diseases and their interpretation.
Blood analysis: Total blood count including ESR, Total serum proteins and their fractions. Blood glucose (GTT) (Fasting and post- prandial), serum lipid fraction–cholesterol, triglyceride, LDL and HDL, blood urea, and serum calcium.
Urine: Creatinine, Glucose and protein (albumin).
Enzymes: SGPT, SGOT and isoenzymes as markers in various disorders and diseases. **12 hrs**

Diseases and Disorders (common occurence):
Aetiology; classification (if any); causative factors; incidence, symptoms and biochemical aspects and markers for-identification, monitoring, prevention and interventions; and nutritional aspects, overweight and obesity. **5 hrs**

Cardiovascular disease: Diabetes, diseases of Liver, Gall bladder & Pancreas-Hepatitis, (A, B, and C), Cirrhosis, alcoholic liver disease, Gall stones, pancreatitis, pancreatic surgery- Causes, Prevention and dietary management. **5 hrs**

Renal disease: Nephrotic syndrome, Acute and Chronic renal failure- diagnostic procedures and dietary management. Dialysis, medical and nutrition therapy. **4 hrs**

Gastrointestinal diseases/disorders: Gastro-oesophageal reflux and esophagitis, Gastritis and Peptic ulcer. Characteristics of and comparison of the stomach and duodenal ulcers. Diagnostic tests for malabsorption, sprue and tropical sprue, Crohn's disease, diarrhoea, constipation, ulcerative colitis, diverticular disease and colon cancer. **8 hrs**

Cancer and HIV/AIDS: Biochemistry of carcinogenesis, types, stages of cancer, diagnosis and existing medicines. Biochemistry of HIV infection, ART and social issues. **4 hrs**

References:
1. Biochemistry; Donald Voet, Judith G. Voet, 4th Edition, John Wiley and sons (2010).
2. Lehninger- Principles of Biochemistry; David L. Nelson and Michael M. Cox, 6th Edition, W. H. Freeman (2013).

3. Biochemistry- The Chemical Reactions of Living Cells; David E. Metzler, 2nd Edition, Academic Press (2001).
4. Outlines of Biochemistry; Eric E. Conn, Paul K. Stumpf, George Breuning, Roy H. Doi, 5th Edition, John-Wiley and sons (2009).
5. Biochemistry- The Chemical Reactions of Living Cells; David E. Metzler, 2nd Edition, Academic Press (2001).
6. Hawk's Physiological Chemistry, ed. Oser, 14th Edn. (1976), Tata-McGraw Hill.
7. Fundamentals of Practical Biochemistry. Mohanty and Basu, BI Publications, India. 2002.
8. 2. Clinical Biochemistry, 2nd Edn. W J Marshall, F I Biol and S K Bangert. Elsevier Health-Mosby Saunders. United States of America. ISBN: 9780443101861.

BCOET – 304.2: Biochemistry in Daily Life

4 units (52 hrs)

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. **5 hrs**

Food and Nutrition: Importance of food for existence of life. Modes of nutrition in life forms – Comparable and contrasting features. **3 hrs**

Human Health and Disease: Nutrition (Health), definition, classification, food and non food sources.
Nutraceuticals; use of nutraceuticals in traditional health sciences. Role of omega-3 fatty acids, carotenoids, dietary fiber, phytoestrogens; glucosinolates; organosulphur compounds in health and disease (prevention and control). **6 hrs**

Prebiotics and probiotics: Mechanics and usefulness of probiotics and prebiotics in gastro intestinal health and other benefits. Beneficiary microbes; prebiotic ingredients in foods; types of prebiotics and their effects on gut microbes.
Functional foods: Definition, development of functional foods, benefits and sources of functional foods in Indian diet. Effects of processing conditions and storage.
Development of nutraceutical and functional foods; Standards for health claims. Process of developing-preclinical & clinical studies. **10 hrs**

Food additives: Definitions, functions and uses in processed food products. Chemical, technological 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. **9 hrs**

Enzymes: Introduction 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. Malting and germination of grains – process, characteristics, nutritional benefits and uses. Domestic use products like detergents. Textiles-Denim processing. Leather industry. **7 hrs**

Food processing and fortification: Principles, objectives and rationale, selection and basis of fortificants. Technology of fortifying cereal products. Characteristics of nutrients used in cereal fortification. Fortification methods. Fortification premixes, Design and composition of premixes and quality control. Fortification of bread, pasta, noodles, biscuits, and breakfast cereals. Beverages; importance of beverage fortification, Health benefits of fortification, Selection of nutrients for fortification, Levels to be added, Characteristics of fortificants and method of fortification, Bioavailability, Organic Vs inorganic salts. *Health foods;* selection of nutrients, Technology of incorporation of fortificants, bioavailability. **12 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. 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).

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