SOUTH KONKAN EDUCATION SOCIETY'S

Govindram Seksaria Science College (Autonomous)

Tilakwadi, Belagavi - 590006

Syllabus

for

M. Sc. Biochemistry (I and II Year)

2024-2025

SCHEME OF STUDY AND EXAMINATION								
Semester	Subject code	**Title of the paper**	Instruction hrs./week	Exam marks			Duration of exam (hrs)	Credits
				Exam	CIA	Total		
I	BCIT- 1.1	Biophysical and Bioorganic Chemistry (Hard Core)	4	80	20	100	3	4
	BCIT- 1.2	Analytical Biochemistry (Hard Core)	4	80	20	100	3	4
	BCIT- 1.3	Biomolecules (Hard core)	4	80	20	100	3	4
	BCIT- 1.4	General Physiology (Hard core)	4	80	20	100	3	4
	BCIT- 1.5	Nutritional Biochemistry **(Soft core)**	2	40	10	50	2	2
	BCIP- 1.6	General Biochemistry	4	40	10	50	2	2
	BCIP- 1.7	Analytical Biochemistry	4	40	10	50	2	2
	BCIP- 1.8	Biomolecules	4	40	10	50	2	2
Total credits for the semester								**24**
II	BCIT- 2.1	Enzymology (Hard core)	4	80	20	100	3	4
	BCIT- 2.2	Metabolism of Fuel Molecules and Bioenergetics (Hard Core)	4	80	20	100	3	4
	BCIT- 2.3	Membrane Biochemistry (Hard core)	4	80	20	100	3	4
	BCIT- 2.4	General Microbiology **(Soft Core)**	2	40	10	50	2	2
	BCIT- 2.5	Bio-Analytical Techniques (**Open Elective**)	4	80	20	100	3	4
	BCIP- 2.6	Enzymology	4	40	10	50	2	2
	BCIP- 2.7	Microbiology	4	40	10	50	2	2
	BCIP- 2.8	Metabolism & Membrane Biochemistry	4	40	10	50	2	2
Total credits for the semester								**24**
III	BCIT- 3.1	Molecular Biology (Hard core)	4	80	20	100	3	4
	BCIT- 3.2	Biochemistry of Cell Signaling (Hard core)	4	80	20	100	3	4
	BCIT- 3.3	Metabolism of Nitrogenous Compounds with Clinical Correlations (Hard core)	4	80	20	100	3	4
	BCIT- 3.4	Gene Regulation (**Soft core**)	2	40	10	50	2	2
	BCIT- 3.5	Biochemistry in Daily Life (**Open Elective**)	4	80	20	100	3	4
	BCIP- 3.6	Molecular Biology	4	40	10	50	2	2
	BCIP- 3.7	Nitrogen Metabolism	4	40	10	50	2	2
	BCIP- 3.8	Cell Signaling	4	40	10	50	2	2
Total credits for the semester								**24**
IV	BCIT- 4.1	Molecular Genetics and Immunology (Hard core)	4	80	20	100	3	4
	BCIT- 4.2	Genetic Engineering (Hard core)	4	80	20	100	3	4
	BCIT- 4.3	Medical Biochemistry (Hard core)	4	80	20	100	3	4
	BCIT- 4.4	Biostatistics & Bioinformatics **(Soft Core)**	2	40	10	50	2	2
	BCIT- 4.5	**Project Work ***	4	80	20	100	-	4
	BCIP- 4.6	Molecular Genetics and Immunology	4	40	10	50	2	2
	BCIP- 4.7	Genetic Engineering	4	40	10	50	2	2
	BCIP- 4.8	Medical Biochemistry	4	40	10	50	2	2
Total credits for the semester								**24**

Scheme for Continuous Evaluation as per the University regulations

Theory Paper (each) of 4 credits	
Attendance:	04 Marks
Tests[#] (C_1 +C_2; 8+8)	16 Marks
Total:	**20 Marks**

[#]*Two tests shall be conducted and factorized to 8 marks each and total marks secured in both tests shall be computed for continuous evaluation*

Theory paper of 2 credits (soft core)	
Attendance:	02 Marks
Tests[#]:	08 Marks
Total:	**10 Marks**

[#]*Two tests shall be conducted and factorized to 4 marks each and total marks secured in both tests shall be computed for continuous evaluation*

Practical (each Practical)	
Practical record	02 Marks
Tests[#]:	08 Marks
Total:	**10 Marks**

[#]*Two tests shall be conducted and factorized to 4 marks each and total marks secured in both tests shall be computed for continuous evaluation*

Project Evaluation	
Project Report	50 Marks
Viva-Voce	30 Marks
Total:	**80 Marks**

Question paper pattern for End semester theory Examination
Hard core papers of 4 credits

Time: 3 h. ***Max. Marks: 80***

Instruction to the students: *Answer Question No. 1 and* ***any four*** of the remaining***.***

Question No. 1 shall have **ten** sub questions (***a - j***) of two marks each, and the student has to answer ***any eight*** of them. **(2X8=16)**

Question No. 2 to 6 carry **sixteen marks** each the student has to answer ***any four*** of them. Main questions shall have three sub questions, wherein question 2 to 5 will have of 5+5+6=16 pattern, and question 6 will have 5 sub questions of 4 marks each and the student has to answer any four of them.

Question paper pattern for End semester theory Examination
Soft-core papers of 2 credits

Time: 2 h. ***Max. Marks: 40***

Instruction to the students: *Answer Question No. 1 and* ***any two*** of the remaining.

Question No. 1 shall have **six** sub questions (***a - f***) of two marks each, and the student has to answer ***any four*** of them. **(2X4=08)**

Question No. 2 to 4 carry **sixteen marks** each, the student has to answer ***any two*** of them. Main questions shall have three sub questions of 5+5+6=16 pattern.

Question paper pattern for end semester Practical Examination
2 credit Practical

Time: 4h **Max. Marks: 40**

1. Give the principle and procedure for …/spotting.	05
2. Perform any one of the experiments listed in the syllabus for the semester.	20
3. Viva-Voce.	10
4. Practical record.	05

BCIT-1.1: Biophysical and Bioorganic Chemistry (Hard Core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Describe the thermodynamic parameters and their variations in homeostasis of cells and its biomolecules and their interaction with water.
- Explain the basic concepts of different types of chemical bonds that can be useful to understand the chemical nature of biomolecules.
- Understand the principle involved in different spectroscopic methods to analyze biomolecules.
- Understand different spectral analysis involved in determining the size, shape and structure of different biomolecules.

UNIT-01 15Hrs

Properties of Water - Physical properties and structure of water, hydrogen bonding and hydrophobic interactions. ionization of water, pH scale, Acids and bases, Henderson-Hasselbalch equation, buffers, buffer capacity, ionic strength, buffer solutions and their action. Importance of buffers in biological systems (cytosol and blood).

Thermodynamics: Laws of thermodynamics, basic concepts of the entropy, free energy changes, standard free energy change, and its relation to the equilibrium constant. Oxidation-reductions in biological systems.

UNIT-02 15Hrs

Stereochemistry: Basic concepts and examples of optical isomerism, chirality, symmetry elements, enantiomers, diastereomers, DL and RS configurations, racemization, resolution racemic mixture, stereoisomerism, and geometrical isomerism (cis-trans) and E – Z notations.

Chemical bonding and Reactions: Properties of covalent bonds, non-covalent bonds, and their importance in biological systems. Types of biochemical reactions: oxidation, reduction, condensation, rearrangement, cleavage, group- transfer, Resonance bond, electrophilic and nucleophilic substitution reactions.

UNIT-03 15Hrs

Spectroscopic techniques: Beer-Lambert's Law and its limitations. Extinction coefficient. Principles of colorimeter, UV-vis spectrophotometer, fluorimeter and their applications. Flow cytometry.

Physical methods of determining size, shape and structure of molecules: Magnetic Resonance: NMR and ESR; principles and applications. **Vibration Spectra:** IR and Raman; principles and applications. Turbidometry, flame photometry, atomic absorption spectrophotometry, instrumentation and applications. MALDI-ToF and ESI. LC-MS, LC-MS-MS.

UNIT-04 **15Hrs**

Electrolytes, Non-Electrolytes and Electrodes: Osmotic pressure, vapor pressure, osmometer, Donnan membrane equilibrium. Hydrogen electrode, electrode potential, and redox potential.

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

Heterocyclic systems: Occurrence, structure, and properties of furon, pyrrole, indole, thiazole, imidazole, and isoalloxazine containing biomolecules. Chemistry of porphyrins and heme and their biological importance.

References

1. Physical Biochemistry. Kansal Edward Van Halde. Prentice Hall.
2. Physical Biology of the Cell, 2ndEdn. Rob Phillips, Jane Kondev, Julie Theriot,Hernan Garcia, Garland Publishers (2012).
3. Bioinorganic Chemistry; Ei-Ichiro Ochiai, Elsevier (2008).
4. Physical Biochemistry. David Frifielder. 2ndEdn. W.G.Freeman and Co ( )
5. Organic Chemistry. Vol. I. Fundamental principles. I. L.Finar. 6thEdn. 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. 6thEdn. Prentice Hall, India.
11. Lehninger- Principles of Biochemistry; DL Nelson and MM Cox [Eds), 6thEdn. Mc MilanPublications (2012).
12. Principles and techniques of practical Biochemistry. K.Wilson and J. Walker. 7thEdn. Cambridge University press (2012).
13. Chemistry- An Introduction to General, Organic and Biological Chemistry, 7thEdn. 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).
17. Biochemistry: The Chemical reactions of living cells volumes I and II by Metzler (2004) Elsevier Science.
18. Outlines of Biochemistry; 1976, by Conn and Stumpf, John-Willey publishers Essentials of Glycobiology, 2nd edition, AjitVarki, Richard D Cummings, ISBN-13: 9780879697709

BCIT-1.2: Analytical Biochemistry (Hard Core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Understand separation and characterization of biomolecules using different chromatographic methods, electrophoretic methods and blotting techniques. Illustrate biochemical calculations, separation, isolation of biomolecules and centrifugation.
- Describe isolation, analysis of biomolecules by chromatography and electrophoresis techniques.
- Describe the characterization of biomolecules by biophysical methods, and application of radioactive isotopes (tracers) in biochemical transformations.
- To develop concepts in techniques used for routine biochemical work such as chromatography, spectrophotometry, centrifugation, microscopy, electrophoresis.

UNIT-01 15Hrs

Chromatography- Introduction, principle, procedure and applications of – Adsorption chromatography, Paper, Thin Layer Chromatography (TLC), Column Chromatography, Gas Liquid Chromatography (GLC), Ion-exchange Chromatography, Gel permeation chromatography, Affinity Chromatography, Reverse phase chromatography, High Performance Liquid Chromatography (HPLC), Fast Performance Liquid Chromatography (FPLC), UPLC and HPTLC.

UNIT-02 15Hrs

Electrophoresis
Principle and applications of Polyacrylamide gel electrophoresis, SDS-PAGE, 2D-electrophoresis, agarose gel electrophoresis, isoelectric focusing, pulsed field electrophoresis and applications. Factors affecting electrophoresis. Blotting techniques – Southern, Northern, Western and their application.

UNIT-03 15Hrs

Centrifugation
Principle of centrifugation, concepts of relative centrifugal forces (RCF) and Svedberg constant. Types of centrifuges and rotors. Differential and Density gradient centrifugation (Zonal and isopycnic). Preparative and analytical ultracentrifugation, Sub-cellular fractionation.
Ultra-filtration and Dialysis: Principles and applications of equilibrium dialysis and ultrafiltration. Artificial membranes, semi-permeable membranes and their applications.

UNIT-04 15Hrs

Microscopic techniques
Principle and applications of Light microscope, contrast, phase contrast, and dark field microscopy, Electron microscopy: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM)**.** Metal shadowing and design. Specimens for electron microscopy.

References

1. Principles of Physical Biochemistry by Van Holde, Johnson and P.S. Ho, (1998) Prentice-Hall, Inc. Jersey.
2. Wilson and John Walker, Cambridge University Press, (2010).
3. Organic chemistry by R.T. Morrison & R.N. Boyd, (2000) Prentice Hall of India, New Delhi.
4. Lenhinger's Principles of Biochemistry D.L. Nelson, David L and M.M. Cox, (2000) Macmillan Worth Pub. Inc. NY.
5. Introduction to Glycobiology Oxford University Press (2001) By Maureen E.Taylor& Kurt Drickamer.
6. Techniques in Molecular Biology, Walker and Gastra, Croom Helm, (1983)
7. Biochemical calculations by Irvin, H. Segel, (1976) John Wiley and sons
8. Biochemistry by Voet, D. and Voet, D.J. (1999) John Wiley and sons
9. Biochemistry Geoffrey L. Zubay, (1998) MCGraw Hill
10. Biochemistry Lubertstrayer, (2001) W.H. Freeman and Co.,
11. Biochemistry J. David Rawn, Etal. (1996), Prentice Hall International, Inc,
12. Metal ions in Biochemistry by P.K. Bhatthacharya (2005) Narosa
13. Concepts in Biochemistry by Boyer 3rdEdn. (2000) John Wiley
14. Biochemistry: The Chemical reactions of living cells volumes I and II by Metzler (2004) Elsevier Science.
15. Outlines of Biochemistry; 1976, by Conn and Stumpf, John-Willey publishers Essentials of Glycobiology, 2nd edition, AjitVarki, Richard D Cummings, ISBN-13: 9780879697709.

BCIT-1.3: Biomolecules (Hard core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Understand structure and classification of carbohydrates, amino acids, lipids proteins and nucleic acids.
- State the role of various biomolecules in health and disease.
- Understand the determination of amino acid composition, sequencing of DNA

UNIT-01 15Hrs

Proteins and Amino acids
Introduction: classification based on source, composition, solubility and functions. Physicochemical properties of proteins.
Structural organizations of proteins:
Primary structure of proteins - determination of primary structure of proteins. Determination of amino acid composition. N- and C-terminal groups. Separation of cleaved fragments and enzymatic methods. Sequential degradation of Edman and solid phase sequencing methods.
Secondary structure – α-helix, β-pleated sheets, β-turns and loops, Ramachandran's plot. Triple helix structure of collagen.

UNIT-02 15Hrs

Tertiary and quaternary structure of Proteins- Forces stabilizing the tertiary and quaternary structure. Super secondary structures. Three - Dimensional structures of globular (Myoglobin, Haemoglobin, Sickle cell haemoglobin - structure and functional relationship) and Fibrous proteins (Collagen, Keratin). Denaturation - Melting temperature, effect of salts, Chaotropic agents. Protein folding and stability, Forces involved in protein folding, Role of chaperones in protein folding. Methods for the determination of protein structure: X-ray, NMR CD and ORD.

UNIT-03 15Hrs

Nucleic acids
Introduction: Structure and composition of nucleic acids, major classes of nucleic acids and their biological role.
Physicochemical properties of nucleic acids: UV absorbance of nucleic acids, hypochromism and Hyperchromism.
Isolation and purification of nucleic acids – DNA and RNA, estimation of nucleic acids.
Primary and secondary structure of DNA: Base composition of DNA, Chargaff's rule, X-ray diffraction analysis of DNA, Watson-Crick model of DNA double helix, Different forms of DNA – A, B & Z.

UNIT-04 **15Hrs**

Tertiary or Higher-order structure of DNA: DNA supercoiling, biological importance of DNA supercoiling, role of topoisomerases. Ribonucleic acids (RNA): Structure of m-RNA, r-RNA and t-RNA, Clover leaf model and L-shaped model of t-RNA.
DNA sequencing: Chemical method of Maxam-Gilbert, Sanger's dideoxy method.
Denaturation and Renaturation of nucleic acids: Melting curves and Tm value of DNA and their significance. Renaturation kinetics– Cot-curves and their significance.

References

1. Lehninger- Principles of Biochemistry; DL Nelson and MM Cox [Eds), 6thEdn. Macmillan Publications (2012).
2. Biochemistry VI Edn; Jeremy M Berg, John L Toymoczko and LubertStryer, 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). 10
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 2ndEd. Benjamin-Cummings (1983).
12. Biochemistry Ed. Donald Voet& Judith G. Voet, John Wiley & Sons, Inc. (2010).
13. Practical Biostatistics; Mendel Suchmacher and Mauro Geller, Academic Press (2012).
14. Biochemistry (IV ed 1998) by Geoffrey L Zubay, McGraw Hill
15. Biochemistry (IV ed 1996) by LubertStryer, WH Freeman and Co., San Francisco.

BCIT-1.4: General Physiology (Hard core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Explain about tissues, processes of blood circulation, and digestion.
- Illuminate respiratory system, cardiovascular system, excretory stem and biochemistry of vision.
- Describe central and peripheral nervous system, synaptic transmission and muscle system.

UNIT-01 15Hrs

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 matrix. Basal lamina; laminins and associated proteins and their functions.

Cytoskeleton: Structure and function of microfilaments, microtubules, (Actin), intermediate filaments (Lamin and Keratin) and microtubules (Centrioles and Cilia). Structure and constituent proteins of erythrocyte cytoskeleton., Cell motility-cilia and flagella.

UNIT-02 15Hrs

Nervous System
Types and structure of neuron. Myelin sheath; composition and function. Resting membrane potential. Mechanism of initiation and propagation of action potential – voltage gated ion channels, ionophores. Neurotransmitters and receptors;
Cerebrospinal fluid (CSF); composition and functions.

Biochemistry of Vision - Structure of rod and cone cells and other cells involved in vision. Photosensitive pigments. Biochemical events occurring in photosensitive cells leading to initiation of nerve impulse.

Muscular System
Ultra structure of smooth, skeletal and cardiac muscle fibers. Contractile and other proteins of muscle. Phosphagens, neuro-muscular junctions, mechanism of muscle contraction. Calmodulin and its regulatory role, muscular dystrophies.

UNIT-03 15Hrs

Digestive System
Composition and functions of saliva, gastric, pancreatic and intestinal juices and bile. Gastro-intestinal hormones. Digestion and absorption of carbohydrates, proteins, and lipids in the gastrointestinal tract. Liver – structure and functions. Detoxification mechanisms. Liver function tests.

Cardio-vascular System
Systemic and pulmonary circulation. Structure of blood vessels. Blood volume, blood pressure. Plasma composition and functions. Mechanism of blood clotting, role of vitamin K, clot dissolution, anti-clotting factors.

UNIT-04 **15Hrs**

Respiratory System
Mechanics and regulation of respiration, pulmonary and alveolar ventilation and its control, transport of respiratory gases.

Excretory System
Mechanism of urine formation and composition of urine. Urine analysis for abnormal constituents, tubular function tests. Nephritis and nephrosis.

Endocrine system
Brief outline of endocrine glands, pituitary, pancreas, adrenal, thyroid, parathyroid, adrenal cortex and their physiological roles.

References

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

BCIT-1.5: Nutritional Biochemistry (Soft Core)

Teaching: 2H/Week **Credits: 2**

30Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- The student will learn and understand the fundamentals of nutrition of carbohydrates and proteins, vitamins macro, micro elements etc.,
- The student with understand the special nutritional aspects during the pregnancy and lactation.

UNIT-01 15Hrs

Carbohydrates
Occurrence and physiological functions, factors influencing metabolism. Lactose intolerance. Dental caries. Artificial sweeteners. Role of dietary fiber in health and disease. 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. Nitrogen balance. Protein efficiency ratio. Methods for evaluating protein quality. Protein-energy malnutrition - clinical features and biochemical changes.

Mineral elements: Sources, functions and deficiency symptoms of Calcium, Phosphorus, Sodium, Potassium, Iron, Zinc, copper, iodine.

UNIT-02 15Hrs

Vitamins
Sources, structure, functions and deficiency symptoms of fat soluble vitamins (A, D, E, K) and water soluble vitamins (B-complex and C).

Energy metabolism
Latest concepts in energy requirements and recommendations for different age groups. BMR and Factors affecting BMR. Energy requirements for different physical activities. Regulation of food intake: role of hunger and satiety centers, the effect of nutrients.

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.

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.
9. The Nutrition Society, London, UK, (2012).
10. Introduction to Human Nutrition, 2nd Edn., Gibney M, Lanham S, Cassidy A and Vorster H. The Nutrition Society, London, UK, (2012).
11. Public Health Nutrition. Gibney M, Margetts B, Kearney J and Arab L. The Nutrition
12. Human Nutrition and Dietetics by Stanley Davidson et.al. (8th ed. 1982) ELBS.
13. Principles of Nutrition and Dietetics by M SwaminathanBapp Co, Bangalore Printing & Publicity, Co. Ltd, Bangalore.
14. Modern Nutrition in Health and Diseases (7th ed. 1988) by Maurice E Skills and V.R. Young, K.M. Varghese Co. Bombay.

BCIP -1.6: General Biochemistry

Duration: 4Hrs/Week **Credits: 2**

1. Standardization of glassware.
2. Preparation of standard solutions and standardization
3. The molar solution, Normal solution, Percentage (W/W, W/V, V/V)
4. Preparation of different buffer solutions.
5. Preparation of acetate buffer
6. Preparation of phosphate buffer
7. Preparation of tris buffer.
8. Preparation of citrate buffer
9. Determination of molar extension coefficient
10. Measurement of pH of solutions by pH meter
11. Titration curves of weak acids and determination of pka of weak acids.
12. Analysis of water: Estimation of Ca by EDTA method
13. Analysis of water: Estimation of Mg by EDTA method

References

1. Modern Experimental Biochemistry by Rodney Boyer (2000) Third edition, Addison Wesley Longman
2. Practical Biochemistry by David Plummer, (1992) Tata McGraw-Hill Publishing
3. Practical Biochemistry: Principles and Techniques, 5 th Edition, Edited by Keith Wilson and John Walker (2000) Cambridge University, Press.
4. Experimental Biochemistry (1976) by John M. Clark and Robert L. Swizer, W.H. Freeman and Company
5. Introduction to Practical Biochemistry (2000) Edited by S.K. Sawhney & Randhir Singh, Narosa Publishing House.
6. Practical Biochemistry by Robit White.
7. Practical Biochemsitry by Deshpande and Rao.

BCIP-1.7: Analytical Biochemistry

Duration: 4 Hrs/Week **Credits: 2**

1. Ascending paper chromatography of carbohydrates
2. Ascending paper chromatography of amino acids
3. Descending paper chromatography of carbohydrates
4. Descending paper chromatography of amino acids
5. Circular chromatography of Carbohydrates
6. Circular chromatography of amino acids
7. Thin layer chromatography
8. Thin layer chromatography of Carbohydrates
9. Thin Layer chromatography of amino acids
10. Separation of plant pigments by adsorption (column chromatography) using silica
11. Separation of plant pigments by adsorption (column chromatography) using alumina
12. Agarose gel Electrophoresis

References

1. Modern Experimental Biochemistry by Rodney Boyer (2000) Third edition, Addison Wesley Longman
2. Practical Biochemistry by David Plummer, (1992) Tata McGraw-Hill Publishing
3. Practical Biochemistry: Principles and Techniques, 5th Edition, Edited by Keith Wilson and John Walker (2000) Cambridge University, Press.
4. Experimental Biochemistry (1976) by John M. Clark and Robert L. Swizer, W.H. Freeman and Company.
5. A Manual Paper Chromatography and paper Electrophoresis by (1955) R.J. Block, E.L. Durrum and G. Zweig, Academic press.

BCIP-1.8: Biomolecules

Duration: 4Hrs/Week **Credits: 2**

1. Qualitative analysis: Amino acids & proteins.
2. Estimation of amino acids by Ninhydrin method
3. Estimation of protein by Lowry's method (FCR reagent)
4. Estimation of protein by Bradford method.
5. Estimation of DNA by Diphenylamine method.
6. Estimation of RNA by Orcinol method.
7. Separation of proteins by native PAGE
8. Determination of Molecular weight of proteins by SDS-PAGE
9. Titration curve of amino acid
10. Estimation of amino acid by formal titration
11. Ultraviolet absorption of nucleic acids
12. Ultraviolet absorption of proteins

References

1. Modern Experimental Biochemistry by Rodney Boyer (2000) Third edition, Addison Wesley Longman
2. Practical Biochemistry by David Plummer, (1992) Tata McGraw-Hill Publishing
3. Practical Biochemistry: Principles and Techniques, 5 th Edition, Edited by Keith Wilson and John Walker (2000) Cambridge University, Press.
4. Experimental Biochemistry (1976) by John M. Clark and Robert L. Swizer, W.H. Freeman and Company.
5. Introduction to Practical Biochemistry (2000) Edited by S.K. Sawhney & Randhir Singh, Narosa Publishing House.
6. A Biologist's Guide to Principles and Techniques in Practical Biochemistry, 3rd edition (1992) by Keith Wilson and Kenneth H. Goulding, Cambridge University Press.

BCIT-2.1: Enzymology (Hard core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Students will understand the functional aspects of different enzymes and inhibition/ mechanism.
- Students will be able to understand the molecular mechanisms of enzyme actions, allosteric regulations and its clinical and industrial applications
- Students will get trained in enzyme kinetics, isolation and characterization.

UNIT-01 15Hrs

Introduction: Role of enzymes in living systems, nature and characteristic features of enzymes. Nomenclature and classification of enzymes. Intracellular localization of enzymes. Enzyme unit - activity, specific activity, molecular activity (turnover number).

Quantitative assay of enzymatic activity by different methods. Immunoassay techniques, flow (continuous, stopped-flow and quenched flow) techniques and their usefulness in the study of enzyme-catalyzed reactions, energy of activation.

Enzyme kinetics

Importance, initial velocity plots, steady-state approximation, evidence for ES complex formation. Michaelis-Menten equation, algebraic derivation of kinetic equation for the determination of K_m and V_{max} parameters, and their significance. Effect of pH, temperature, substrate concentration in enzyme activity and kinetics, Methods of kinetic analysis- Lineweaver Burk, Eadie Hofstee, Hanes and Dixon plots.

UNIT-02 15Hrs

Enzyme inhibition

Reversible and irreversible inhibition, Types of reversible inhibitors–competitive, noncompetitive, uncompetitive, mixed inhibitors, substrate inhibition, graphical representations.

Kinetics of bi-substrate enzyme-catalyzed reactions

Sequential, ordered, random, ping pong, theoroll-chance mechanisms and their Cleland's representations with examples. Graphical analysis, King-Altman procedure for deriving kinetic equation for single substrate and two substrate reactions. Investigations of reaction mechanisms using isotopic – exchange at equilibrium.

Molecular basis of enzymes catalysis

General theories and hypotheses proposed to explain enzyme specificity, lock and key, induced- fit theory, and contribution of structural flexibility to the specificity of enzymes.

UNIT-03 15Hrs

Factors contributing to catalytic efficiency of enzymes

Proximity and orientation effect, acid-base covalent catalysis (nucleophilic and electrophilic), metal ion catalysis.

Active site characterization

Method of active site group assignment. The identification of binding sites and catalytic sites,

chemical modification of the active site, amino acid side chains, active site-directed reagents (irreversible inhibitors), the use of substrate analogs, pseudo substrate, photoaffinity labeling, suicide inhibitors and trapping of ES complexes.

3-D Structure of enzymes

General aspects of 3D structural features of enzymes as revealed by X-ray and chemical studies. Mechanism of action of following enzymes: Based on physicochemical and 3-D structural data- Lysozymes, RNase and chymotrypsin, including zymogen activation. eg. Chymotrypsinogen.

UNIT-04 **15Hrs**

Different forms of enzymes

Isozymes, multienzyme complexes, multifunctional enzymes, ribozymes, coenzymes and metalloenzymes, abzymes.

Allosteric enzymes

Identification and their characterization co-operativity, the Hill equation, the Scatchard plot and equilibrium dialysis techniques. Sigmoidal kinetics: The MWC & KNF models with examples, the significance of sigmoidal behavior. Regulatory features of ATCase.

Regulatory mechanisms

Regulation of enzymatic activity, fine control availability of substrates and cofactors, steady-state fluxes, flux of metabolites through metabolic pathway. Types of feedback regulations.

Applications of enzymes

Immobilized enzymes- Clinical and Biotechnological applications of enzymes, temperature resistant enzymes.

References

1. Enzymes by Paul Boyer, Vol.I & II Academic press.
2. Lehininger's principles of biochemistry (2000) by Nelson, David L and Cox, M.M. Macmillan/Worth, NY.
3. Enzyme kinetics by Roberts D.V. (1997) Cambridge Univ. Press.
4. Enzyme kinetics by I.H. Segel (1996) Interscience-Wiley
5. Understanding of enzymes by Palmer, (2003) T. Ells &Horwood Ltd
6. Enzymatic reaction mechanism (1979) by Christopher Wlash, Freeman Pub., San Francisco.
7. Methods in Enzymology; Colowick. S.P. et.al., [Eds]. Different volumes, Academic press.
8. Fundamentals of Enzymology, N.C. Price and Lewis (2000) Oxford University, Press.
9. Intermediary metabolism and regulation by J. Larner
10. Biochemistry (V Ed 2001) Lubertstryyer, W.H. Freeman and Co.,
11. Biochemistry (III Ed 1999) Voet, D. and Voet J.G. Jhon Wiley and Sons.
12. Biochemistry (II Ed 1996) J. David Rawn, Etal., Prentice Hall International, Inc,
13. Enzyme Engineering: protein engineering, Structure prediction and Fermentation
14. M.J.C. Crabbe (1990) Ellis Horwood.
15. Immobilized enzymes by M.D. Trevan (1980), John Wily and Sons.
16. Industrial Applications of Enzymes, Wolfgang Ahle

BCIT-2.2: Metabolism of Fuel Molecules and Bioenergetics (Hard Core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Students will learn and understand the various metabolic pathway that occur in the human body and also energy production.
- The student will be able to Explain the metabolism of Carbohydrates, Lipids, Photosynthesis process.
- Illustrate plant-cell, growth regulators, metabolism, biotic and abiotic stress responses.
- Describe plant cell and photorespiration.

UNIT-01 **15Hrs**

Lipids

Lipid classification, brief account of the chemical properties and structure of lipids (without structure elucidation) & biological role of the following: fatty acids (PUFA), triacyl glycerols (TAG), phospholipids (plasmalogens), sphingolipids, glycolipids, prostaglandins, and steroids.

Metabolism

Oxidation of fatty acids: even and odd numbered, unsaturated and branched chain fatty acids. Degradation of triacylglycerols and phospholipids. β-oxidation of fatty acids and its energetics. Metabolism of ketone bodies; their formation, oxidation and clinical significance. Biosynthesis of triacylglycerols, phospholipids and sphingolipids. Cholesterol biosynthesis, catabolism and regulation. Lipoproteinemias, fatty liver, hypercholesterolemia. Chemical composition, biological functions and metabolic fate of VLDL, LDL and HDL.

UNIT-02 **15Hrs**

Carbohydrates

Monosaccharides- classification with structures. Sugar derivatives - alcohols, acids, amino sugars, deoxysugars, glycosides. Di and Oligosaccharides structure and linkages in lactose, maltose, and sucrose, raffinose series oligosaccharides. Polysaccharides- Homo and heteropolysaccharides, glycosaminoglycans. Glycoconjugates- structural features and biological functions of Proteoglycans and Glycoproteins (O-linked and N-linked). Isolation and analysis of carbohydrates.

Metabolism

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.

UNIT-03 **15 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. Pentosuria, fructose and lactose intolerance, fructosuria, galactosemia.

Photosynthesis: Introduction, Phytosynthetic organisms, pigments, light and dark phases, Photosynthetic apparatus in plants, Hill reaction, role of photosystems I and II. Electron flow and photophosphorylation; cyclic and noncyclic, Calvin cycle (C3), Hatch slack pathway (C4). Photorespiration, bacterial photosynthesis. RUBISCO.

UNIT-04 **15Hrs**

Basic concepts of bioenergetics, review of first and second law of thermodynamics, entropy, free energy, standard free energy change and equilibrium constant of reactions, ATP as universal currency of biological energy. Generation of ATP in living systems, redox potential, biological redox couples, Free energy changes in electron transfer reactions.

Oxidative phosphorylation–Mitochondrial electron transport chain, components, role of inhibitors, uncouplers and ionophores in understanding mechanism of oxidative phosphorylation; chemiosmotic theory; substrate level phosphorylation, futile cycle, thermogenesis, brief account on ATP- synthase and P/O ratio.

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. Textbook of Biochemistry with Clinical correlations; Thomas Devlin [Ed.] (1997), Wiley -Liss.
4. Principles of Biochemistry; Lehninger et al., [Eds.] (1997) 2nd Edn. Worth Publishers.
5. Principles of Biochemistry; Smith et al., [Ed.] (1986) McGarw Hill.
6. Bioenergetics; A Practical Approach, G.C. Brown and C.E. Cooper (1995) IRL- Oxford University Press. 7. Photosynthesis, D.O. Hall and K.K. Rao, (1999), 6 thEdn. Cambridge University Press.
7. Hawk's Physiological Chemistry, Oser (1976) 14 thEdn Tata-McGraHill.
8. Photosynthesis. Ed. A.S. Raghavendra, (2000), Cambridge University Press.
9. Recent Advances in Plant Biochemistry; S.L. Mehta, M.L. Lodha, and P.V. Sane, (1992) ICAR, New Delhi

BCIT-2.3: Membrane Biochemistry (Hard core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Explain membrane composition and transport.
- Illuminate composition of biological membrane and motion of membrane constituents.
- Describe various transport systems across biological membranes of prokaryotes and eukaryotes.

UNIT-01 15Hrs

Introduction
Molecular constituents of membrane: Lipid composition, Proteins, Sterol, Carbohydrates. Physicochemical properties of biological membranes; compositions, supra molecular organization.
Models of membrane: Gorter and Grendel's experiment, bilayer structure, Danielle - Davson model of membrane. Evolution in concept of membrane models, Singer and Nicholson's model.

UNIT-02 15Hrs

Membrane proteins: peripheral proteins and integral proteins. Membrane asymmetry, protein-lipid interactions, factors affecting membrane fluidity. The supramolecular architecture of membrane: Unit membrane hypothesis, fluid model, fluid-mosaic model, Membrane protein dynamics.

Membrane asymmetry; lipids, proteins and carbohydrates and their lateral diffusion. Biogenesis of lipids and proteins, polarized cells, membrane domains; caveolae, rafts, membrane lipid and protein turnover, intracellular targeting of proteins.

UNIT-03 15Hrs

Membrane transport: Introduction to membrane transport, Laws of diffusion across membranes, simple diffusion, facilitated diffusion and active transport. Glucose transporters, Ca2+ ATPase, Na+-K+ ATPase (Structure and mechanism of action). Endocytosis, receptor mediated endocytosis, exocytosis, ion channels; gated and non-gated, aquaporin channel.

UNIT-04 15Hrs

Methods of study of membrane structure: Lipid transfer proteins, phospholipases, chemical methods, amino-phospholipid translocation, freeze fracture and freeze etching. Lipid vesicles; liposome preparations and application, function of sterols in membranes.
Techniques used to study membrane structure: FRET, FRAP, confocal microscopy of membrane dynamics. Cell fusion, shedding of membrane.

References

1. Biochemistry 5thEdn. Jeremy M. Berg, John L. Tymoczko, LubertStryer.
2. Harper's Illustrated Biochemistry; 27th Edn. Robert K. Murray, Daryl K. Granner, Victor W. Rodwell, The McGraw-Hill (2006).
3. Lipid Biochemistry; 5thEdn. Michael I. Gurr, John L. Harwood and Keith N. Frayn, Blackwell Science (2002).
4. Biochemistry of Lipids, Lipoproteins and Membranes; 5thEdn. 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; 6 thEdn. Bruce Alberts, Alexander Johnson, Julian Lewis,
10. David Morgan, Martin Raff, Keith Roberts and Peter Walter; Garland Science (2014).
11. Molecular Cell Biology; Lodish et al., 7thEdn. W.H. Freeman and Co. (2012).

BCIT-2.4: General Microbiology (Softcore)

Teaching: 2H/Week **Credits: 2**

30Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Students will understand the properties and special aspects of microorganisms.
- Students will be able to understand the applications of microbes in the field of medicine, microbial disease and industrial importance.

UNIT-01 15Hrs

Introduction to Microbiology: Historical development and scope of microbiology and microbial Biotechnology.

Classification of microorganisms:
Nomenclature, study of different types of microorganisms, and characteristics of the main groups of microorganisms.

Cultivation of bacteria
Types of microbial culture, common problems with bacterial cultures, culture methods for cultivation of bacteria, Nutritional requirements for the bacteria, Growth curve of bacteria and the factors affecting growth curve, chemostat, synchronous and diauxic growth. Measurement of growth, cell number– methods of enumeration. Study of bacterial cell structures–genetic elements, ribosomes, membranes, cell envelopes, capsule, flagella, pili and endospores. Bacterial life cycle.

Identification of bacteria
Staining methods- Gram staining and Acid-fast staining, structure and differences between Gram- negative and Gram-positive bacteria.

Bacteriology of milk and Flora of the normal human body.

Bacterial toxins - Classification**:** exotoxins and endotoxins, chemical nature and associated diseases.

UNIT-02 15Hrs

Viruses-Classification and properties of viruses. Animal and plant virus and viral diseases. Bacteriophages – Structure, mode of infections – Lytic cycle and transudation – specialized, generalized and abortive. Interferons, clinical importance of viruses – HIV, Hepatitis A and B virus, RNA & DNA tumor viruses and cancer.

Food Microbiology: Production of cheese, pasteurization of milk, contamination of milk and its prevention, food spoilage, food preservation.

Environmental microbiology and energy: Biomass production, biogas, Environmental pollution and degradation, Use of microbes in pollution control.

Fermentation technology: Fermentation, design and construction, Production of ethanol from molasses. Production of Beer and Wine. Production of penicillin and streptomycin.

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,WileyLiss (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)
15. Industrial MicrobiologyPrescott and Dun

BCIT- 2.5 Bio-Analytical Techniques. (Open Elective)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- To know different chromatographic techniques.
- To study the principle and applications of different electrophoretic and spectroscopic techniques.

UNIT-01 15Hrs

Introduction: Analyzing and reporting of experimental data-significant figures, scientific notation, units, error analysis and precisions in estimations, tables, controls and blanks. Solutions and buffers.
Chromatographic techniques: Principles and applications of PC, TLC, GLC adsorption, Ion exchange, gel permeation, affinity chromatography and HPLC.

UNIT-02 15Hrs

Spectroscopic techniques: Principles and application of calorimetry, spectrophotometry and spectrofluorimetry.
Centrifugation techniques: Cell disruption devices-homogenization and sonication application of differential and density gradient centrifugation. Dialysis and ultra-filtration.

UNIT-03 15Hrs

Electrophoretic techniques: Principle and application of polyacrylamide, SDS-PAGE and agarose electrophoresis. Blotting techniques-western and southern.
Immunological techniques: RIA, ELISA.

UNIT-04 15Hrs

Radio Isotope techniques: Units of radioactivity. Stable and radioactive isotopes, Liquid scintillation counter, applications in biology, Autoradiography.

References

1. Analytical Biochemistry: D.J. Holme and H.Pick (1983) Longman.
2. Biochemical calculations, Irvin, H. Segel, (1976) John Wiley and sons.
3. Biochemistry: David Rawn, J. (1989) Neil Patterson Publishers.
4. Modern experimental Biochemistry by Rodney Boyer (2000), 3rd edition, Addison Wesley Longman.
5. Practical Biochemistry: Principles and Techniques, 5th edition, Editied by Keith Wilson and John Walker (2000) Cambridge University, Press.
6. An Introduction to Practical Biochemistry by David Plummer (1992) McGraw Hill Publishing.
7. Biochemical Techniques (1990) by John F Robyt and Birnard J. White waveland press inc.

BCIP -2.6: Enzymology

Duration: 4Hrs/Week **Credits: 2**

1. Standard curve of alpha napthol.
2. Determination of Km and Vmax of pea esterase.
3. Determination of optimum pH of pea esterase.
4. Determination of pH stability of pea esterase.
5. Determination of optimum temperature of pea esterase.
6. Determination of temperature stability of pea esterase.
7. Effect of inhibitor on activity of pea esterase.
8. Determination of total activity of salivary β-amylase using sweet potato.
9. Determination of total activity of salivary β-amylase using germinated ragi.
10. Determination of Km and Vmax of α-amylase.
11. Determination of Km and Vmax of acid phosphatase.
12. Determination of nature of inhibitor of IC_{50} (acid phosphatase).
13. Determine the effect of inhibitor on activity of acid phosphatase.

References

1. Modern Experimental Biochemistry by Rodney Boyer (2000) Third edition, Addison Wesley Longman
2. Practical Biochemistry by David Plummer, (1992) Tata McGraw-Hill Publishing
3. Practical Biochemistry: Principles and Techniques, 5 th Edition, Edited by Keith Wilson and John Walker (2000) Cambridge University, Press.
4. Experimental Biochemistry (1976) by John M. Clark and Robert L. Swizer, W.H. Freeman and Company
5. Introduction to Practical Biochemistry (2000) Edited by S.K. Sawhney&Randhir Singh, Narosa Publishing House.
6. A Biologist's Guide to Principles and Techniques in Practical Biochemistyr, 3rd edition (1992) by Keith Wilson and Kenneth H. Goulding, Cambridge University Press

BCIP-2.7: Microbiology

Duration: 4 Hrs/Week **Credits: 2**

1. Preparation of culture media
2. Sterilization by dry heat and moist heat – autoclaving.
3. Isolation and preparation of pure cultures of bacteria
4. Isolation and preparation of pure cultures of fungi
5. Identification of bacteria by morphological and biochemical tests.
6. Gram staining and other staining procedures
7. Antibiotic sensitivity test for microbial cultures
8. Bacterial growth curve
9. Production of Wine by fermentation.
10. Fermentation of Sauerkraut to produce lactic acid.
11. Estimation of percentage of lactic acid.
12. Estimation of percentage of calcium.

References

1. Biology of Microorganisms by M.T. Modigam, J.M. Matinko& J. Oanker, 8thEdn. (1999) Prentice Hall
2. Microbes in action by H.W. Seeley and P.J. Vendomark (1975) W.H. Freeman
3. Laboratory methods in microbiology by W.F. Haccigan& M.E. Mccanca
4. Applied Microbial Physiology; a practical approach Rhodes and Stanbury (1997) IRL Press.
5. Basic and practical microbiology, Ronald L. Atlas (1986) McMillan Publication Co.

BCIP-2.8: Metabolism & Membrane Biochemistry

Duration: 4Hrs/Week **Credits: 2**

1. Qualitative analysis: Carbohydrates,
2. Quantitative estimation of Sugars by Phenol – Sulfuric acid.
3. Quantitative estimation of starch by Anthrone method.
4. Quantitative estimation of reducing sugars by Hagedorn-Jenson method.
5. Quantitative estimation of reducing sugar by Nelson-Somogyi method
6. Quantitative estimation of glucose by DNS method.
7. Determination of blood Glucose by Sasaki method
8. Determination of Saponification value
9. Determination of Iodine value of oils
10. Determination of acid value of fats
11. Isolation of Cholesterol from egg yolk
12. Estimation of cholesterol by Zack's method
13. Spectral characterization of Chlorophyll
14. Estimation of Vitamin C by Colorimetric method (2,6 Dichlorophenol indophenol method).

References

1. Modern Experimental Biochemistry by Rodney Boyer (2000) Third edition, Addison Wesley Longman.
2. Practical Biochemistry by David Plummer, (1992) Tata McGraw-Hill Publishing
3. Practical Biochemistry: Principles and Techniques, 5th Edition, Edited by Keith Wilson and John Walker (2000) Cambridge University, Press.
4. Experimental Biochemistry (1976) by John M. Clark and Robert L. Swizer, W.H. Freeman and Company
5. Introduction to Practical Biochemistry (2000) Edited by S.K. Sawhney & Randhir Singh, Narosa Publishing House.
6. A Biologist's Guide to Principles and Techniques in Practical Biochemistry, 3rd edition (1992) by Keith Wilson and Keneth H. Goulding, Cambridge University Press.
7. Practical Biochemistry by Robit White.
8. Practical Biochemsitry by Deshpande and Rao.
9. Electrophoresis by (1955) R.J. Block, E.L. Durrum and G. Zweig, Academic press.
10. Introduction to Practical Biochemistry (2000) Edited by S.K. Sawhney & Randhir Singh, Narosa Publishing House.
11. A Biologist's Guide to Principles and Techniques in Practical Biochemistry, 3rd edition (1992) by Keith Wilson and Kenneth H. Goulding, Cambridge University Press.
12. Practical Biochemistry by Sadashiva and Manikam

BCIT-3.1: Molecular Biology (Hard core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Illustrate central dogma, DNA replication, gene expression, damage and repair mechanisms.
- Explain DNA as genetic material, DNA replication in prokaryotes and eukaryotes.
- Describe DNA-protein, protein-protein interactions and DNA dependent RNA synthesis.
- Explain genetic code, protein synthesis, post-translational modifications and targeting.
- Illustrate regulation of gene expression, DNA damage and repair in prokaryotes and eukaryotes.

UNIT-01 15Hrs

DNA replication: Semiconservative mode of replication. Experimental evidences, DNA unwinding, Topological problems, linking numbers and role of topoisomerases, direction of replication DNA polymerases I, II and III their role in DNA synthesis, Termination of replication. Nearest neighboring frequency analysis. Mechanism of E. coli replication. Single standard DNA, synthesis of phage DNA, rolling cycle model. Replication of eukaryotic and mitochondrial DNA, restriction and modification of DNA. Inhibitors of DNA replication.

UNIT-02 15Hrs

Transcription in Prokaryotes & Eukaryotes

Prokaryotic transcription

Detailed account of *E. coli* RNA polymerase, mechanism of initiation, elongation, and termination.

Eukaryotic Transcription

Transcription Unit, Basal transcription operators of RNA Polymerases, mechanism of initiation (TATA box,TATA less promoters), elongation by RNA polymerase II, role of transcription factors in transcription initiation & activation. Inhibitors of prokaryotic and Eukaryotic RNA polymerase.

UNIT-03 15Hrs

RNA processing

Processing of pre rRNA in prokaryotes & Eukaryotes. Processing of pre mRNA in Eukaryotes, splicing, catalytic RNA, Self -splicing RNA.

Post transcriptional modification of Eukaryotic RNA, tRNA processing (pre t RNA), mRNA stability (Poly A tail & 5' capping).

Ribosome structure- subunit composition of Prokaryotic & Eukaryotic ribosomal subunits.

Genetic Code- Experimental methods of deciphering genetic code, historical account of genetic code- contribution of Nirenberg & Har Gobind Khurana. Properties of Genetic code- Wobble Hypothesis, collinearity of genes & proteins. Mitochondrial genetic code, codon usage & bias.

UNIT-04 **15Hrs**

Translation and protein targeting: Structural organization of ribosomes in prokaryotes and eukaryotes. Role of mRNA and tRNA in protein biosynthesis. Stages in protein biosynthesis. Site and direction of protein biosynthesis. Amino acid activation. Formation of amino acyl tRNA, chain initiation, elongation and termination. Mechanism of synthesis of proteins. The role of various factors. Post translational modification of proteins. Inhibition of protein biosynthesis in eukaryotic and prokaryotic system, protein targeting, synthesis of secretary and membrane proteins., signal sequence hypothesis. Mechanism of translational control.

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)

BCIT-3.2 Biochemistry of Cell Signaling (Hard core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- To acquire knowledge on cell signalling, cancer, cell death and fundamentals of bioinformatics.
- To study principles and proteins of cell signalling and communication, signal recognition.
- To learn intracellular signaling-regulation, protein kinases, cancer and apoptotic signalling.

UNIT-01 15Hrs

Principle of Signal transduction: Definition of Cell Signaling, general principles of cell signaling and communication; various forms of communication between cells; signaling process and its stages – Signal recognition, transduction and cellular effect; Types of cell signaling – Autocrine signaling, Direct contact signaling, Paracrine signaling, Synaptic signaling, Endocrine signaling. First messenger, glands and types of secretions, ligands, agonists, antagonists, receptors for first messengers, second messengers, soluble second messengers, membrane bound second messengers.

G-Protein coupled receptor system: Characteristic features of Receptor. Intra cellular - Receptors for nitric oxide, steroid hormone receptors, and thyroid hormone; Cell surface receptors - G- protein coupled receptors, cytokine receptors, Receptor tyrosine kinases, TGF β receptors, Hedgehog (Hh) receptors, Wnt receptors, Notch receptors, insulin receptor, growth hormone receptor.

UNIT-02 15Hrs

Intra cellular signaling proteins; adaptors, activators, integrators and effectors. Effectors on intracellular signaling- Adenylate cyclase, Phospholipase-C, Nitric oxide synthase, guanylate cyclase and their activation.

Hormonal signaling: Structure of hormone receptors, mechanism of ligand receptor interaction-intracellular and membrane receptor mediated responses. MAPK pathway, Role of second messenger cAMP, cGMP, Ca^{+2}, inositol triphosphate (IP_3), diacylglycerol DAG and nitric oxide (NO) and their synthesis and biological role.

UNIT-03 15Hrs

Protein Kinases: Functional classification of protein kinases; Ca2+/calmodulin-dependent protein kinases, CdKs, Janus kinases, GSK, RLKs types and specificity; structure and regulation of protein kinases and role of phosphatases.

Apoptosis and necrosis: Apoptosis–Programmed cell death. Cellular changes underlying apoptosis. Factors resulting to cell death. Necrosis-types and physiological signal and cellular changes underlying necrosis. Inflammosomes - role in death of infected cells autophagy and significance.

UNIT-04 **15Hrs**

Carcinogenesis: Mechanism of carcinogenesis. Characteristics of cancer cells, Types of cancer, benign and malignant tumors. Cancer metastasis, carcinogens (chemical, physical and biological), Ames test for carcinogenicity.

Cancer: Clinical and classical signs, different types and stages, diagnostic tests, chemotherapy (natural and synthetic drugs), kidney and liver toxicity, radiation therapy, Molecular basis of cancer and cell differentiation.

Cell Cycle: G0, G1, S, G2 and M-phases of cell cycle - Characteristics of each phase of cell cycles. Restriction points of cell cycle and Quiescent cells, Synchronization of mammalian cells-its importance. Determination of the length of each phase of cell cycle.

References

1. Biochemistry of Signal Transduction and Regulation, Gerhard Krauss, 5th Edn. Wiley-VCH Verlag GmbH & Co (2014).
2. Text Book of Biochemistry with Clinical Correlations – Thomas H. Devlin (2005) 6th edition. John Wiley and sons.
3. Biopharmaceuticals Biochemistry and Biotechnology 2nd Edn. Gary Walsh, John Wiley & Sons, Ltd, England (2003).
4. Basic Neurochemistry; George Siegel et al., Wippincott, Williams and Wilkins (1999).
5. The Biochemistry of Cell signaling; Ernst J.M. Helmreich, OUP, (2001).
6. Signal transduction and human disease; Toren Finkel, and J. Silvio Gutkind, John Wiley& Sons, Inc. (2003)
7. Greenspan's Basic and Clinical Endocrinology; 9th Edn. David Gardner and Dolores Shoback Lange Clinical Medicine (2012).
8. Biochemistry of Signal Transduction and Regulation; Gerhard Krauss, Wiley-VCH.
9. Text book of cell signaling and cancer; Jacques Robert (2019) Springer Publishers.
10. Cell Signaling-Principle and Mechanism; Wendell Lim, Bruce Mayer, Tony Pawson (2014); Garland Science press.

BCIT-3.3 Metabolism of Nitrogenous Compounds with Clinical Correlations (Hardcore)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Students will learn the metabolic pathways relevant to catabolism and anabolism of nitrogen compounds and its associated disease in related enzymes or amino acids or nucleic acids.
- Discuss nitrogen metabolism and general mechanisms of amino acid metabolism.
- Describe pathways of degradation of proteins, purines and pyrimidines and Inborn errors of amino acid degradation
- Identify important metabolites in plants and animals that are important to understand the significance of various metabolic pathways.

UNIT-01 15Hrs

Nitrogen Cycle: Introduction, biological and non-biological nitrogen fixation. Assimilation of ammonia, formation of amino acid amides by glutamine synthetase and its regulation.
General metabolic reaction of amino acids: Transamination (mechanism), pseudo-transamination, 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 norepinephrine).

UNIT-02 15Hrs

Catabolism of 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.
In born errors of amino acid degradation - Phenyl Ketonuria, alkaptonuria, maple syrup urine. Albinism, Histidinaemia, homocysteinuria, Alkaptanuria.

UNIT-03 15Hrs

Anabolism of amino acid: Biosynthesis of the individual amino acids: 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.

UNIT-04 **15Hrs**

Nucleotide Biosynthesis: Biosynthesis of purine and pyrimidine nucleotides and their inter-conversion, regulation of biosynthesis. Other pathways of purine nucleotide formation (salvage pathway). 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.

10Hrs

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. Textbook of Biochemistry with Clinical correlations; Thomas Devlin [Ed.] (1997), Wiley - Liss.
4. Principles of Biochemistry; Lehninger et al., [Eds.] (1997) 2nd Edn. Worth Publishers.
5. Principles of Biochemistry; Smith et al., [Ed.] (1986) McGarw Hill.
6. Bioenergetics; A Practical Approach, G.C. Brown and C.E. Cooper (1995) IRL- Oxford University Press.
7. Photosynthesis, D.O. Hall and K.K. Rao, (1999), 6 th Edn. Cambridge University Press.
8. Hawk's Physiological Chemistry, Oser (1976) 14 th Edn Tata-McGraHill.
9. Photosynthesis. Ed. A.S. Raghavendra, (2000), Cambridge University Press.
10. Recent Advances in Plant Biochemistry; S.L. Mehta, M.L. Lodha, and P.V. Sane, (1992) ICAR, New Delhi.

BCIT-3.4: Gene Regulation (Soft Core)

Teaching: 2H/Week **Credits: 2**

30Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Understand the regulations of gene in both prokaryotes and eukaryotes.
- Understand the operon model, DNA binding protein motifs and Regulation at the level of post translational modification.

UNIT-01 **15Hrs**

Regulation of Gene Expression in Prokaryotes: Principles of regulation of gene expression. Outline of transcriptional regulation, Induction, repression. Genes involved in regulation; regulator, promoter, operator and structural genes- activators and repressors. Riboswitches.

The operon model: Regulation of gene expression at transcriptional level. Concept of positive regulation and negative regulation. Operon concept- study of structure and regulation of Lac operon, Jacob and Monod hypothesis- Catabolite repression; role of cAMP and cAMP-receptor protein (CRP/ CAP) in the expression of glucose-sensitive operons, structure and functions of CAP. Structure, function and regulation of tryptophan operon in E. coli, Concept and process of negative regulation, repression and attenuation in tryptophan operon. Structure and regulation of arabinose operon, and histidine operon.

UNIT-02 **15Hrs**

Eukaryotic gene expression: Levels of control of gene expression in eukaryotes. Regulation of gene expression in yeast. Control of galactose genes in yeast. Histone modifications. Brief study of regulation of developmental genes in Drosophila.

DNA binding protein motifs: Zinc finger, leucine zipper, helix-turn-helix and other motifs. **Regulation at the level of post translational modifications**: proteins stability, N-end rule, ubiquitin mediated degradation. Mechanism of miRNA, siRNA, RNAi, ENCODE.

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. Molecular Biology; Robert F. Weaver, Mc Graw-Hill (2018).
4. Epigenetics and Epigenomics; Christopher J. Payne, INTECH, (2014).
5. Gene Control; David Latchman, Garland Science (2010).
6. Molecular Cell Biology; Harvey Lodish, Arnold Berk, Chris A. Kaiser, 7th Edition, W. H. Freeman (2012).
7. Molecular Biology of the Cell; 7th Edn. Bruce Alberts et al., (2008), Garland Publications
8. Evolution of the Human Genome I, Saitou, The Genome and Genes, Naruya (Ed.) Springer (2017).
9. Nuclear Organization; Chromatin Structure and Gene Expression, Roen Van Driel and Arie

P. Otte (1997) Oxford University Press.
10. Human Molecular Genetics; Peter Sudbery, (2002) Printice Hall.

BCIT-3.5 Biochemistry in daily Life (Open elective)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Illuminate biochemistry of food and nutrition, functional foods and health foods.
- Explain biochemistry of food and nutrition, prebiotics and probiotics.
- Describe functional foods, enzymes in fruit beverages, malting, fortification and health foods.

UNIT-01 15Hrs

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 microconstituents of unicellular and multicellular organisms.
Food and Nutrition: Importance of food for existence of life. Modes of nutrition in life forms –Comparable and contrasting features.

UNIT-02 15Hrs

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 in health and disease (prevention and control).
Prebiotics and probiotics: Mechanics and usefulness of probiotics and prebiotics in gastro intestinal health and other benefits. Beneficiary microbes.
Functional foods: Definition, development of functional foods, benefits and sources of functional foods in Indian diet.

UNIT-03 15Hrs

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.
Sweetening agents: Artificial sweeteners, composition, uses. Natural and synthetic colors, food Flavors, Spices and flavoring constituents, flavors in food industries.
Enzymes: Introduction and essentiality to life forms. Use of enzyme in beverages.
Malting and germination of grains – process, characteristics, nutritional benefits and uses.

UNIT-04 15Hrs

Food processing and fortification: Principles, objectives and rationale, selection and basis of fortificants. Characteristics of nutrients used in cereal fortification. Fortification methods. 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.

References

1. Biochemistry Ed. Donald Voet & Judith G. Voet, John Wiley & Sons, Inc. (2010).
2. Lehninger- Principles of Biochemistry; D.L.Nelson and M.M. Cox, 7th Edn. MacMillan Publications (2017).
3. Nutrition: Science and Applications, 3rd Edn. Lori A. Smolin, Mary B. Grosvenor, Wiley (2013).
4. Introduction to Human Nutrition, 2nd Edn. Michael J. Gibney, Susan A. Lanham-New, Aedin Cassidy, Hester H. Vorster, Wiley-Blackwell (2009).
5. Nutrition: Everyday Choices, 1st Edition; Mary B. Grosvenor, Lori A. Smolin Wiley (2006).
6. Bioactive Food as Dietary Interventions for Liver and Gastrointestinal Disease; Watson Elseveir (2012).
7. Food, Nutrition and Health. Tapsell L. Oxford University Press (2010).

BCIP-3.6: Molecular Biology

Duration: 4 Hrs/Week **Credits: 2**

1. Isolation of genomic DNA from bacteria (E. coli).
2. Quantification (Spectrophotometric and agarose gel electrophoresis) of genomic DNA from bacteria (E. coli).
3. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of genomic DNA from plant (Cauliflower).
4. Isolation of genomic DNA from animal Liver (Goat/Sheep).
5. Quantification (Spectrophotometric and agarose gel electrophoresis) of genomic DNA from animal Liver (Goat/Sheep).
6. Isolation of RNA from bacteria.
7. Primer designing for PCR
8. Amplification of DNA using PCR
9. RT PCR - Demo
10. Southern Blotting
11. Phage titration
12. Estimation of RNA by Orcinol method.
13. Estimation of DNA by DPA method.
14. Studies of DNA & RNA by UV Spectroscopy

References

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

BCIP-3.7: Nitrogen Metabolism

Duration: 4 Hrs/Week **Credits: 2**

1. Amino transferase coenzyme
2. Determination of ATP in biological system (Inorganic phosphate after hydrolysis)
3. Estimation of Urea
4. Estimation of Uric acid
5. Estimation of Glutathione
6. Determination of Nucleotide coenzyme (NAD+, FAD)
7. Haemoglobin Detection Sacy's method

References

1. Varley's Practical Clinical Biochemistry, 6thEdn. (1996) by Alan H. Gowenlock
2. Hawk's Physiological chemistry by Oser. (14thEdn 1976) Tata McGraw Hill publishing, company Ltd.

3. Clinical Biochemistry by Warley (1980) Vol. 1 & 2, Heinemann Medical
4. Modern Experimental Biochemistry by Rodney Boyer (2000) Third edition, Addison Wesley Longman
5. Practical Biochemistry by David Plummer, (1992) Tata McGraw-Hill Publishing
6. Practical Biochemistry: Principles and Techniques, 5th Edition, Edited by Keith
7. Wilson and John Walker (2000) Cambridge University, Press.
8. Experimental Biochemistry (1976) by John M. Clark and Robert L. Swizer, W.H. Freeman and Company
9. Introduction to Practical Biochemistry (2000) Edited by S.K. Sawhney & Randhir Singh, Narosa Publishing House.

BCIP-3.8: Cell Signalling

Duration: 4 h/Week **Credits: 2**

1. 17 Keto steroids in urine.
2. Estimation of acetylcholine esterase from serum or rat, goat brain (Signal transduction).
3. Estimation of phosphorylated enzyme, tyrosine (from std curve of Tyrosine), ATP tyrosine kinase crude extract.
4. Identification of different stages of mitosis from onion root tips.
5. Identification of different stages of meiosis from onion buds.

References

1. Modern Experimental Biochemistry by Rodney Boyer (2000) Third edition, Addison Wesley Longman
2. Practical Biochemistry by David Plummer, (1992) Tata McGraw-Hill Publishing
3. Practical Biochemistry: Principles and Techniques, 5th Edition, Edited by Keith
4. Wilson and John Walker (2000) Cambridge University, Press.
5. Experimental Biochemistry (1976) by John M. Clark and Robert L. Swizer, W.H. Freeman and Company
6. Introduction to Practical Biochemistry (2000) Edited by S.K. Sawhney & Randhir Singh, Narosa Publishing House.

BCIT-4.1: Molecular Genetics & Immunology (Hard core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Students will learn how human body fights with invading microorganism and pathogens.
- Students will understand the human genetics and related components.

UNIT-01 **15Hrs**

Molecular Genetics

Bacterial genetics: Bacterial chromosome, plasmids, fertility, resistance, colicins, virulent, metabolic and other factors. Transposable genetic elements, recombination in bacteria.
Human Genetics: Pedigree analysis, Lod score for linkage testing, Karyotypes, genetic disorders. Structural & Numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, Ploidy and their genetic implications. Chromosomal disorders: Structural and numerical; autosomal/sex chromosomal/sex reversal.

Mutations: Types, mutagens, nature of mutation, mechanism of action of mutagens, suppressor mutation, genes and their importance, Temperature sensitive mutants, isolation of auxotrophic and nutritional mutant microbe's replica plating.
DNA repair: Photoreaactivation, Excision, Post-replication and Recombinational DNA repair mechanisms.

UNIT-02 **15Hrs**

Immunology

Organs and cells of the Immune system. Primary (Structure of Bone-marrow and Thymus) and secondary lymphoid organs. Haematopoiesis (Cells of Myeloid and lymphoid lineages), Production and maturation (Ontogeny) of T (TH, TC and TREG) and B (B1 and B2) lymphocytes.

Innate Immune Response: Mechanical barriers to infection, Physiological factors contributing to innate immunity, Inflammatory response and Phagocytic system (Role of Mononuclear phagocytes, Macrophages, Neutrophils in innate immunity). Types of infections and nature of infective agents, Alternate and classical pathway of complement system

Immunogenetics: Genetic model compatible with Ig structure, Multigene organization of Ig genes, Variable-region gene rearrangements and its mechanism, Theories of antibody formation (Clonal selection and Network). Molecular basis of antibody diversity–gene recombination, somatic hyper mutation, N- and P-nucleotide insertion, Class switching, Regulation of Ig-Gene Transcription.

UNIT-03 **15Hrs**

Antigens and Antibodies: Chemical complexity and molecular property of Antigens, Haptens, Epitopes, Paratope. Epitope analysis, Basis of antigen specificity. immunoglobulin fine structure and classes, Antigenic determinants on immunoglobulins, Immunoglobulin superfamily, monoclonal and polyclonal antibodies and their production by hybridoma technology.

Antigen-Antibody Interactions: Principles, affinity and avidity and cross reactivity. Techniques - Precipitation, Agglutination, Radioimmunoassay, Enzyme-Linked Immunosorbent Assay, Immunofluorescence, Immuno-electron Microscopy.

Adaptive immune response: Primary and secondary immune response. Nature of T and B cell surface receptors, Major Histocompatibility Complex- Molecular organization of MHC molecules (H-2, HLA), Structure of MHC molecules. Class I MHC-peptide and Class II MHC-Peptide interactions. Antigen presenting cells (APCs), Antigen processing and presentation by endo and exogenous pathways.

UNIT-04 **15Hrs**

Immune effector mechanisms – Immunological tolerance, Hypersensitivity: Immediate (type I, type II, type III) and delayed hypersensitivity reactions.
Autoimmunity- Organ specific (Hashimoto's thyroiditis and Myasthenia Gravis) and systemic (Rheumatoid arthritis and Systemic lupus erythematosus) diseases.
Cytokines: Properties and functions of lymphokines, monokines, interleukins and chemokines; Transplantation Immunology: autograft, allograft, isograft and xenograft, Mechanism of graft rejection and Immunosuppressive therapy.

References

1. Biochemistry (V Ed 2002) Lubertstrayer, W.H. Freeman and Co.,
2. Biochemistry (III Ed 1999) Voet, D. and Voet J.G. Jhon Wiley and Sons.
3. Molecular Cell Biology, 4th edition, (2000) by Lodish Harvey, Arnold Berk, S. Lawrence Ziursky, Paul Matsufaira, Daid Baltimore, James Durnel (W.H. Freeman and Company)
4. Genes VII Benjamin Lewin (Ed 2000) University Oxford Press
5. Microbial Biotechnology by Alexander, Glaser &ItiroslniNikaido 2ndedn Freeman and Co. (1998)
6. Molecular conning: A Laboratory manual, 3rdedn. (2001) by J. Sambrock and Russel, Spring Horbour Laboratory press.
7. Principles of Gene Manipultion 6thEdn. (2001) by S.B. Primose, R.M. Tqyman, R.W. Old, Blankwell Scientific
8. Molecular Biology of the cell by Alberts et al., (1989) Garland publications
9. DNA Clonning: A Practical approach by D.M. Gover (1985) Vol. 1. and 2, IRL press.
10. Basic & Clinical Immunology (4thedn.) by Daniel P, Stabo, John D. Fudenberg H, Hugu, Wells, J. Vivian Stites (1982) Lange
11. Roitt's Essential Immunology; Ivan M. Roitt& Peter J Delves (2001) Blackwell Science
12. Immunology/Ivan Roitt, Jonathan Brostoff, David Male (6thedn.) (2001) Mosby
13. Introduction to Immunology; Kim bell (Ed) (1990) 3 Ed McMillan
14. Kuby-Immunology; Goldsby et al., (2006), W.H. Freeman & Co.

BCIT-4.2: Genetic Engineering (Hard core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Explain fundamentals of recombinant DNA technology, restriction endonucleases and vectors.
- Describe cloned DNA expression, recombinant proteins and applications of rDNA technology.
- Understand the principle and methodology employed in DNA recombinant technology
- Understand the various plasmids/vectors in cloning.
- Understand the applications of transgenic animals, plants, gene therapy and their negative impact.

UNIT-01 15Hrs

Concept and emergence of recombinant - DNA technology: Gene- concept, structure and organization, basic techniques involved in rDNA technology.
Vectors: Ideal properties of a vector, Plasmids, Isolation and purification of plasmid. Natural plasmids, pSC 101, artificial plasmids - pBR322, pUC.
High capacity vectors - Cosmids, Phagemids, brief overview of vectors based on plant and animal viruses, Ti-plasmid. Artificial chromosomes (YAC, BAC, HAC).

UNIT-02 15Hrs

Introduction of DNA into cells: Transformation, transfection, chemical methods: calcium phosphate method, electroporation, microinjection, gene gun, Short gun approach, lipofection, protoplast fusion/somatic cell hybridization and biolistic methods.
Selection and screening of recombinant clones: Direct screening (Blue white screening), Indirect screening (antibiotics).
Genomic and cDNA libraries: Criteria for the construction of an ideal genomic library, cDNA synthesis and library construction, chromosome walking, chromosome jumping, selection of a clone from library.

UNIT-03 15Hrs

Applications of recombinant DNA technology: Production of recombinant proteins in bacterial and eukaryotic cells – Recombinant insulin, growth hormone, factor VIII, recombinant vaccines and antibiotics. Genetically modified plants and GM foods. Ethical, legal and social issues related to genetic engineering.
Gene transfer in animal's cell: Gene transfer by viral vectors; adeno and baculo viruses, retro viral vectors. Gene therapy and gene editing; CRISPR.
Gene transfer in plants: Plant cell culture and protoplast, callus and their manipulations. Agrobacterium mediated transformation. Ti-plasmid, mechanism of T-DNA transfer, function of T-DNA genes.
Cloning in yeast: development of yeast vectors, YIP. YEP, YAC selection and expression of clones.

UNIT-04 **15Hrs**

Introduction and Scope of Biotechnology

Expression of foreign DNA: Comparison of transcription initiation signals in prokaryotic and eukaryotic. Lac promoter, trp promoter. Synthesis of eukaryotic proteins on commercial scale production of insulin, diagnostic probes of genetic diseases, site specific mutagenesis.

Plant biotechnology: Plant tissue culture, isolation of plant protoplasm's -Ti-plasmid or agrobacterium tumer faceins and other bacteria, caulimo virus. Introduction of desirable gene in plants. Phage mediated transfer, Application of transgenic plants, Salinity & drought resistant plants, insect resistant plants, Golden rice.

Cell biotechnology: Animal cell culture, cloning in mammalian cells transgenic animals, methods of introducing genes into eukaryotic cells and chromosomes, reproductive and therapeutic cloning, gene therapy.

Biosensors: Principle of biosensors and biochips and their applications.

References

1. Molecular Cloning; A laboratory manual; Michael R. Green, CSHL Press (2012).
2. Molecular Biology of the Cell; 7th Edn. Bruce Alberts et al., (2008), Garland Publications
3. Molecular Biology; Robert F. Weaver, McGraw Hill (2018).
4. Principles and Techniques of Biochemistry and Molecular Biology; 7th Edn. Keith Wilson and John Walker (2010).
5. Principles of Gene Manipulations; 6th Edn. S.B. Primrose, R.M. Twyman, and R.W. Old, Blackwell Science (2012).
6. Gene Cloning and DNA analysis- An Introduction; T. A. Brown, 5th Edition, ileyBlackwell Publishing (2006).
7. Molecular biology and Biotechnology; 4th Edn., J.M. Walker and R. Rapley, RSC (2000).
8. Plant Biotechnology and Agriculture; Arie Altman and Paul Hasegawa Academic Press (2011).

BCIT-4.3 Medical Biochemistry (Hard core)

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Students will able to understand the blood groups, blood components and their disorder and diagnostic studies.
- The clinical application of enzymes and their role in diagnosis
- To understanding, the various physiological role of kidney, liver, cardiac, gastric tract etc.

UNIT-01 **15Hrs**

Introduction and Scope of medical Biochemistry

Haematology and Haematological disorders: Composition of Blood, signification of plasma proteins. Development and maturation of erythrocytes and leukocytes. Different types of Anaemias Microcytic, macrocytic and normocytic. 'CBC' complete blood count. Total, differential and platelet counts and their clinical significance. Blood group substances, Rhessus factor, 'Rh' typing. 'ABO' and 'Rh' incompatibility (single and combined) and the dangers involved in foetal development and subsequent measures to reduce Haemoglobinopthies, porphyries. 'ESR' (Erythrocyte sedimentation rate) determination and its importance in the diagnosis of certain diseases. Disorders of haemoglobins- thalassemmia, sickle cell anaemia.

Enzymes of clinical and diagnostic importance: Enzymes as markers in the diagnosis of diseases. Clinical significance of cholinesterase, alkaline and acid phosphatase, Lactate dehydrogenase (LDH), Creatine phosphokinase (CPK), Aspertate amino transferase (AST/SGOT), Alanine aminotransferase (ALT/SGPT).

UNIT-02 **15Hrs**

Biochemical investigations in Kidney diseases: Kidney profile Urine analysis for normal and abnormal constituents, urine microscopy culture, and antibiotic sensitivity test. Clearance test and their importance in the assessment of kidney function. Kidney diseases like urinary tract infection (UTI), Urolithiasis. Dialysis and kidney transplants.

Biochemical investigations in Liver diseases: Liver profile in health and disease. Hepatocellular functions. Liver function tests (LFT), and their clinical significance in the diagnosis of liver diseases like cirrhosis and jaundice. Gallbladder stone analysis and its clinical significance, Hepatatis A, B, &C infections.

Gastric profile in heath and disease; Gastric function test, hypo and hyper acidity, ulcers. Stetorrhea, and malabsorption syndrome, with special emphasis on stool (faeces) examination.

UNIT-03 **15Hrs**

Disorders of Lipid metabolism- Plasma lipoproteins and their functions, Hyperlipoproteinaemia- classification, Primary and secondary, Hypercholesterolemia, Ketosis and its significance. **Disorders of amino acid and protein metabolism**- Inborn errors of amino acid metabolism- PKU, Alkaptonuria. **Disorders of purine and pyrimidine**

metabolism - Gout, Lesch-Nyhan syndrome, Xanthuria, Oroticaciduria. **Cardiovascular disorders**- Major cardiovascular system- Atherosclerosis- risk factors, pathogenesis, diagnosis and prognosis. **Gastrointestinal disorders:** Fractional gastric analysis, Hypo and hyperacidity, Gastric ulcers, Malabsorption syndrome.

UNIT-04 **15Hrs**

Cardiac profile in health and disease: Brief mention of heart diseases
Diabetes mellitus: regulation of blood sugar, classification, stages and diagnosis (urine analysis, GTC/GTT, Glycosylated hemoglobins and fructosamine determinations. Role of antidiabetic oral drugs and insulin therapy.
Serology: Diagnostic importance of serological test like the pregnancy, WIDAL, VDRL tests, Malaria. Importance of lab accreditation and quality control in a clinical biochemistry laboratory.

References

1. Tietz text book of clinical chemistry (2ndedn) C.A. Beutis, E.R. Ashwood (eds) Saunders WB, Co. 2058 1994.
2. Robbins, Pathologic basis of disease 2/5thedn. (Robbis, Cotran, Jumar (W.B.Sauders Co) (1995)(Prism Books Bangalore).
3. Davidson's Principles and Practice of Medicine (17thedn) (1995) C.Haslett, E.R. Chilvers (Churchill- Livingstone).
4. Clinical laboratory diagnosis by S.A Levinson and R.P MACFATE 7thEdn (1969) Lea and Febigea.
5. Biochemical actions of Hormones by G. Litewck (Ed) Voll-14, 1973-1987, Academic press.
6. Endocrinology by L.G. Groot (Ed). 1995, Sandeers.
7. Principles of Biochemistry by GeofferyZubay, William W. Parson, Dennis E. Vance. (latest Edn).
8. Text Books of Biochemistry with clinical correlations by T.M Devlin (1997), John Wiley and Sons.
9. Dhamdher, D.M. (2012). Operating Systems: A concept Based Approach. New Delhi: Jain Publishing.
10. Vittal, N. and Mahalingam, S. (2001). Information Technology: India's Tomorrow. New Delhi: Manas.
11. Text book of Biochemistry and Human Biology –Talwar, G.P. and Srivastava. L.M., Printice Hall of India.
12. Clinical biochemistry, 2nd Edn. W J Marshall, F I Biol and S K Bangert. Elsevier Health-Mosby Saunders. United States of America. ISBN: 9780443101861.

BCIT-4.4 Biostatistics and Bioinformatics (Soft Core)

Teaching: 2H/Week **Credits: 2**

30Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- Understand the collection and graphical representation of statistical analysis.
- Understand the various means of statistical analysis including t test, ANOVA, correlation and regression.
- To study fundamentals of bioinformatics, databases, data retrieval from databases and analysis.
- To learn sequence alignment and database searching.

UNIT-01 **15Hrs**

Biostatistics

Introduction to Biostatistics - Aim, scope, definition and elementary idea of statistics in biology.
Basic terminology – population, sample, variable, primary and secondary data, screening and representation of data, tabulation and diagrammatic representation of statistical data, pie charts.
Measures of central tendency and dispersion: Mean, median, mode. Measures of dispersion; range, variance, standard deviation, standard error, coefficient of variation, symmetry, measures of skewness and kurtosis.
Bivariate data: Scatter plot, correlation coefficient (r) - positive and negative correlation, properties (without proof), interpretation of r, linear regression.
Tests of significance: Sample test (chi square, t-test, F –test), large sample test (Z test) and standard error, p value of the statistics, ANOVA- one way and two-way classification.

UNIT-02 **15Hrs**

Bioinformatics

Introduction, Definition and Scope of Bioinformatics, Inter-relationship with various branches of life sciences.
Biological Databases: Definition, types and importance. Classification of databases - Database management system, RDBMS, Database management public agencies. NCBI data model, structures of EBI and Genome Net, GenBank Sequence database.
Data Retrieval from databases and Analysis: Database search engines - Entrez and DBGET/Link DB, SRS. Searching sequence databases by similarities criteria, FASTA, BLAST and its variants.
Sequence alignment and database searching: Introduction, protein and nucleic acid sequence analysis, Models of sequence analysis.

15Hrs

References

1. Biostatistics, P. Ramakrishanan, Saras publications, Kanyakumari.
2. Fundamentals of biostatistics, Khan and Khanum.

3. Basic Biostatistics-Suresh Kumar and Satyaveri, Campus books
4. Developing Bioinformatics Computer Skills; Cynthia Gibas et al., (2001) Shroff Publishers.
5. Introduction to Bioinformatics; Lesk, A.M. (2002).
6. Introduction to Bioinformatics; T K Attwood & D J Parry-Smith, (2002), Pearson Education.
7. Bioinformatics – sequence and genome analysis; David W. Mount, Cold spring Harber
8. laboratory.
9. Structural Bioinformatics-Philip E. Bourne and Helgeweissing, John Wiley and Sons.
10. Introduction to Bioinformatics- a therotical and Practical Approach.

BCIT-4.5 Project Work / Dissertation

Teaching: 4H/Week **Credits: 4**

60Hrs

Course Outcomes: On successful completion of the course, the students will be able to

- After rigorous training during their project tenure, students will able to gain comprehensive hands on training in the field of various research fields such as Biodegradation, Glycobiology and Phytonanotechnology.
- Literature survey on the topic.
- Basics of research methodology and design of experiments.
- Execution of research work by various techniques.
- Preparation of manuscript for publication.
- Presentation of research data in the conferences/seminars.

Project work: Project work will be on defined research topic allotted to the students. The project work includes designing experiments, generating results, analysis of results and writing a comprehensive project report.

BCIP-4.6: Molecular Genetics and Immunology

Duration: 4H/Week **Credits: 2**

1. Karyotyping -which chromosome is affected (Down's syndrome, Klinefelter syndrome, trisomy, tetrasomy)
2. Pedigree analysis
3. Cells, organs and immune system.
4. Separation of serum and plasma from whole blood
5. Precipitation of IG from serum (NH4)2 SO4/Na2SO4
6. Double diffusion & Radial Immunodiffusion (Ouchterlony & Mancini's method)
7. Western blot
8. Estimation of Ab Biuret, FCR method
9. Determination of bleeding time by Duke's method
10. Determination of clotting time.
11. Identification of ABO and Rh blood group
12. Estimation of haemoglobin.

References

1. Molecular Cloning; A laboratory manual; Michael R. Green, CSHL Press (2012).
2. Molecular Biology of the Cell; 7th Edn. Bruce Alberts et al., (2008), Garland Publications.
3. Molecular Biology; Robert F. Weaver, McGraw Hill (2018).
4. Principles and Techniques of Biochemistry and Molecular Biology; 7th Edn. Keith Wilson and John Walker (2010).
5. Methods in Immunology and Immunochemistry; Curtis Williams, Academic Press (1971).
6. Immuno Assay Hand Book; David Wild, Elsevier (2013).
7. Basic Methods for the Biochemical Lab; Martin Holtzhauer, Springer, (2007).
8. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8th Edn. Andreas Hoffman and Samuel Clockie, Ed., Cambridge University Press, (2018).
9. Laboratory Techniques in Biochemistry and Molecular Biology, Work and Work Vol. I & II, North Holland, (1969).
10. Principle and Techniques of Practical Biochemistry; Keith Wilson and John M. Walker, Cambridge University Press (2000).
11. Laboratory Techniques in Biochemistry and Molecular Biology, Work and Work Vol. I & II, North Holland, (1969).
12. Biophysical Tools for Biologists In Vivo Techniques; John Correia H. Detrich, III Elsevier (2008).

BCIP-4.7 Genetic Engineering

Teaching: 4H/Week **Credits: 2**

1. Preparation of competent cells
2. Transformation of DNA by CaCl2 method (recombinant vectors – plasmids / phages)
3. Isolation purification and electrophoretic separation of plasmid DNA from bacterial cells
4. Restriction digestion of isolated plasmid DNA
5. DNA ligation Demonstration
6. Isolation of DNA from bacterial cells
7. Characterization of DNA by UV Spectroscopy
8. Estimation of DNA by DPA method.

References

1. Biochemical Techniques-theory and practical by John T. Robert and Bernad J White
2. Biotechnology laboratory course 2ndedn. By Jeffery M. Becker, Guy A Caldwell and Eve Ann Zachicago
3. Modern Experimental Biochemistry by Rodney Boyer (2000) Third edition, Addison Wesley Longman
4. Practical Biochemistry by David Plummer, (1992) Tata McGraw-Hill Publisher
5. Practical Biochemistry: Principles and Techniques, 5th Edition, Edited by Keith Wilson and John Walker (2000) Cambridge University, Press.
6. Molecular Biology Techniques; Sue Carson, Heather Miller and D. Scott Witherow, Academic Press (2011).
7. Principles and Techniques of Biochemistry and Molecular Biology; 7th Edn. Keith Wilson and John Walker (2012).
8. Principles of Gene Manipulations; 6th Edn. S.B. Primrose, R.M. Twyman, and R.W. Old, Blackwell Science (2012).
9. Gene Cloning and DNA analysis- An Introduction; T. A. Brown, 5th Edn, Wiley Blackwell (2006).

BCIP- 4.8: Medical Biochemistry

Teaching: 4H/Week **Credits: 2**

1. **Urine Qualitative analysis**
   Urine Analysis: Urine qualitative analysis for normal and abnormal constituent and urine microscopy for cells, casts and crystals.
2. **Quantitative analysis of urine**
   a. Total titratable acidity
   b. Glucose
   c. Inorganic phosphorus
   d. Creatine and creatinine
3. **Blood /serum quantitative analysis**
   a. Glucose
   b. Bilirubin
   c. Cholesterol
   d. Urea
   e. Uric acid
   f. creatinine
4. Quantitative estimation of 17 keto steroids in urine.

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1. Varley's Practical Clinical Biochemistry, 6thEdn. (1996) by Alan H. Gowenlock
2. Hawk's Physiological chemistry by Oser. (14thEdn 1976) Tata McGraw Hill publishing, company Ltd.
3. Clinical Biochemistry by Warley (1980) Vol. 1 & 2, Heinemann Medical Modern
4. Experimental Biochemistry by Rodney Boyer (2000) Third edition, Addison Wesley Longman