Mahatma Gandhi University

Kottayam

Syllabus for B.Sc. Course in Biochemistry under Credit- Semester System

2009 – 2010 Onwards

Biochemistry is both a life science and a chemical science - it explores the chemistry of living organisms and the molecular basis for the changes occurring in living cells. It uses the methods of chemistry, physics, molecular biology and immunology to study the structure and behaviour of the complex molecules found in biological material and the ways these molecules interact to form cells, tissues and whole organisms, cellular multiplication and differentiation, communication within and between cells and organs, and the chemical basis of inheritance and disease. The biochemist seeks to determine how specific molecules such as proteins, nucleic acids, lipids, vitamins and hormones function in such processes.

Biochemistry has become the foundation for understanding all biological processes. It has provided explanations for the causes of many diseases in humans, animals and plants. It can frequently suggest ways by which such diseases may be treated or cured. Because biochemistry seeks to unravel the complex chemical reactions that occur in a wide variety of life forms, it provides the basis for practical advances in medicine, veterinary medicine, agriculture and biotechnology. It underlies and includes such exciting new fields as molecular genetics and bioengineering.

As the broadest of the basic sciences, biochemistry includes many subspecialties such as neurochemistry, bioorganic chemistry, clinical biochemistry, physical biochemistry, molecular genetics, biochemical pharmacology and immunochemistry. Recent advances in these areas have created links among technology, chemical engineering and biochemistry.

GENERAL OBJECTIVES

The Course intends to provide students with sufficient knowledge of biomolecular structure to understand the determining properties of biological function at the level of cells and the body. This will allow students at a later stage:

- To understand physiology and physiopathology at the molecular level; the molecular basis of diagnosis, therapeutics, disease prevention and health promotion.
- Become familiar with and understand the basic structures and functions of cells in the human body, applying biomedical concepts and terminology.
- Apply biochemical analysis and reasoning in order to solve problems related to physiology and cellular physiopathology.
- Learn to use a biochemical approach in the study of cellular functions that will provide an understanding of future advances in the molecular bases of physiology, physiopathology, diagnostics, therapeutics, disease prevention, health promotion and the continuous updating of knowledge.

The Course aims to prepare students:

- To acquire and apply the relevant biochemical information in order to solve potential biomedical problems.
- Provide students with basic theoretical and practical knowledge of the principal methodologies and techniques for investigation of biomolecules; operation, potential and limitations and selected personal experiences of laboratory work. Understand the theoretical and practical basis of biochemistry as applied to the investigation and measurement of cell functions.
- Assist students in understanding the scientific method.
- Help students develop observation and critical analysis skills: collection, evaluation and classification of data; deducing conclusions; formulating hypotheses.
- Assist students in developing self-learning and the ability to keep knowledge and skills up to date; team work and communication.

Mahatma Gandhi University

B.Sc. Course in Biochemistry under Credit- Semester System

Semester	Course Title	Hours/ week	Credit	Total credit
First semester	Common English I	5	4	20
	Common English II	4	3	
	Common Second language I	4	4	
	BC1B001U: Cellular Biochemistry	**2**	**2**	
	BC1B001U: Core Practical I	**2**	**1**	
	First complementary course- 1	2	2	
	First complementary practical- 1	2	1	
	Second complementary course- 1	2	2	
	Second complementary practical- 1	2	1	
Second semester	Common English III	5	4	20
	Common English IV	4	3	
	Common Second language II	4	4	
	BC2B002U: Physical aspects of Biochemistry	**2**	**2**	
	BC2B002U:Core Practical II	**2**	**1**	
	First complementary course- 2	2	2	
	First complementary practical- 2	2	1	
	Second complementary course- 2	2	2	
	Second complementary practical- 2	2	1	
Third semester	Common English V	5	4	20
	Common Second language III	5	4	
	BC3B003U: Methods in Biochemistry	**3**	**3**	
	BC3B003U: Core Practical III	**2**	**1**	
	First complementary course- 3	3	3	
	First complementary practical- 3	2	1	

	Second complementary course- 3	3	3	
	Second complementary practical- 3	2	1	
Fourth semester	Common English VI	5	4	20
	Common Second language IV	5	4	
	BC4B004U: Biomolecules	**3**	**3**	
	BC4B004U:Core course practical- IV	**2**	**1**	
	First complementary course- 4	3	3	
	First complementary practical- 4	2	1	
	Second complementary course- 4	3	3	
	Second complementary practical- 4	2	1	

Semester	Course Title	Hours/ week	Credit	Total credit
Fifth semester	**BC5B005U: Physiological Aspects of Biochemistry**	**3**	**3**	20
	BC5B006U: Immunology and Immunological Techniques	**3**	**3**	
	BC5B007U: Enzymology and Enzyme Technology	**3**	**3**	
	BC5B008U: Metabolism and Bioenergetics	**3**	**3**	
	BC5B005U: Core Practicals V **BC5B006U: Core Practicals VI** **BC5B007U: Core Practicals VII** **BC5B008U: Core Practicals VIII**	**2** **2** **2** **3**	**1** **1** **1** **1**	
	BC5D001U Choice based Open Course offered to students of other Departments	4	4	
Sixth semester	**BC6B009U - IX: Genetics and Molecular Biology**	**3**	**3**	20
	BC6B010U: Clinical Biochemistry	**3**	**3**	
	BC6B011U: Pharmaceutical Biochemistry	**3**	**3**	
	BC6B012U: Soil Biochemistry	**3**	**3**	
	BC6B009U: Core Practicals IX **BC6B010U: Core Practicals X** **BC6B011U: Core Practicals XI** **BC6B012U: Core Practicals XII**	**2** **3** **2** **2**	**1** **1** **1** **1**	
	BC6B013U: Core Choice based Course offered to students of Biochemistry Department	4	3	
	Project work		1	

Choice based Open Course offered to students of other Departments (5th Semester)

1. **BC5D001U:** Health and nutrition: 4 credits.
2. **BC5D002U:** Environmental Biochemistry: 4 credits
3. **BC5D003U:** Waste management: 4 credits

Core Choice based Course offered to students of Biochemistry Department (6th Semester)

1. **BC6B013U:** Health and Nutrition: 3 credits
2. **BC6B014U:** Biochemical and Environmental Toxicology: 3 credits
3. **BC6B015U:** Plant biochemistry: 3 credits

4. **BC6B016U:** Waste Management 3 credits

BC1B001U: Core Course I: **Cellular Biochemistry**

Total hours of instruction: 36. Hours/week: 2. Credit: 2

Objective: Introduces the student to the world of Science and Cellular Biochemistry

Unit I: (7 h)
Introduction to Philosophy of Science - Relationship between History and Philosophy of Science - Basic Components of Science - Scientific Reasoning • Deduction and Induction - Observation and Measurement • Inference - Probability and Induction - Experimentation and Realism - Scientific Explanation • Reductionism and Unity of Science Scientific Change and Progress - Inductivism and Falsificationism - Paradigms and Research Programmes - Science as Problem-Solving and Technologism - Science & Technology - Science and Values

Unit II: (8 h.)
Origin of life on Earth - The theory of Extraterrestrial contact - import of life through meteorites, Theory of Chemical Evolution, Primitive Earth Conditions • anoxic reductive atmosphere, relatively high temperature, Volcanic eruption, radioactivity, high frequency UV radiation. Abiotic formation of sugars, amino acids, organic acids, purines, pyrimidines, glycerol and formation of nucleotides and their polymerization to RNA on reactive Surfaces, polymerization of amino acids to Polypeptides and Proteins. Ribozymes and RNA World, Formation of DNA, Formation of nucleoproteins, Prions, Natural Selection of Self replicating Polymers

Ref: - Windows to the Universe, at http://www.windows.ucar.edu/
Cell biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. verma and V. K. Agarwal (2008) Publisher: S. Chand & Company Ltd ISBN: 81-219-2442-1 p141

Unit III: (8 h.)
Discovery of cell and Cell Theory; Comparison between plant, animal and microbial cells, Sub cellular particles and marker enzymes, Nucleus, chromosomes, mitochondria, chloroplast, ribosomes, endoplasmic reticulum, golgi complex, lysosomes, Cytoskeleton, (microfilaments, microtubules and intermediate filaments), glyoxysomes and peroxysomes.

Ref: - Cell biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. verma and V. K. Agarwal (2008) Publisher: S. Chand & Company Ltd ISBN: 81-219-2442-1 p 3, 32, 69, 154, 166, 175, 184, 191, 243, 280, 293

Unit IV: (6h.)
Plasma membrane- structure and composition, Membrane composition and organization: Fluid mosaic model, Membrane fluidity. Transport across membranes. Exocytosis, Endocytosis, Simple diffusion, facilitated transport- definition, types with examples. Symport, uniport and antiport, Active transport- Primary active transport, secondary active transport, Ion channels, sodium/potassium-ATPase, V type, P type and F type transports.

Ref: - Cell biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. verma and V. K. Agarwal (2008) Publisher: S. Chand & Company Ltd ISBN: 81-219-2442-1 p112

Unit V: (7 h.)
Cell cycle- different phases including cell division - Mitosis and meiosis (fundamental study), Apoptosis- definition, difference between apoptosis and necrosis and outline study of apoptotic pathways, role of

caspases; tumor - benign and malignant. Properties of malignant cells

Ref: - Cell biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. verma and V. K. Agarwal (2008) Publisher: S. Chand & Company Ltd ISBN: 81-219-2442-1 p 318

Suggested Readings

Molecular Biology of the Cell by Bruce Alberts, Alexander Johnson, Julian Lewis

- , Martin Raff
- , Keith Roberts, Peter Walter Publisher: Garland Science; 5 edition ISBN-10: 0815341059 ISBN-13: 978-0815341055
- The Cell by Geoffrey M. Cooper, Robert E. Hausman Publisher: Sinauer Associates Inc.,U.S.; 4th Revised edition edition (26 Jun 2006) ISBN-10: 0878932208 ISBN-13: 978-0878932207
- Cell and Molecular Biology by E. D. P. De Robertis Publisher: Lea & Febiger; 8 Sub edition (June 1987) ISBN-10: 0812110129 ISBN-13: 978-0812110128
- Molecular Cell Biology by J. E. Darnell, H. Lodish, David Baltimore
- Publisher: W.H. Freeman & Company (May 1986) ISBN-10: 0716714485 ISBN-13: 978-0716714484
- **Windows to the Universe**, at http://www.windows.ucar.edu/ at the University Corporation for Atmospheric Research (UCAR). © The Regents of the University of Michigan *Windows to the Universe*© is a registered trademark of UCAR

© The origin of species By Charles Darwin, Gillian Beer Contributor Gillian Beer Edition: reissue, illustrated Published by Oxford University Press, 1998 ISBN 019283438X, 9780192834386

© Life on a Young Planet: The First Three Billion Years of Evolution on Earth By Andrew H. Knoll Edition: illustrated Published by Princeton University Press, 2004 ISBN 0691120293, 9780691120294

- Philosophy of Science: A Very Short Introduction by Samir Okasha (2002) Publisher: Oxford University Press, USA; ISBN-10: 0192802836, ISBN-13: 978-0192802835
- Philosophy of Science by by David Boersema (2008) Publisher: Longman; ISBN-10: 032143711X, ISBN-13: 978-0321437112
- Worldviews: An Introduction to the History and Philosophy of Science by Richard DeWitt (2004) Publisher: Wiley-Blackwell ISBN-10: 140511620X, ISBN-13: 978-1405116206

BC1B001U: Core Practicals I

Total hours of instruction: 36. **Hours/week: 2.** **Credit: 1**

Objective: Introduce the students to basic technique of Cell fractionation and separation of sub cellular organelles.

1. Cell Fractionation

- Homogenization media preparation
- Homogenization of Tissue samples
- Preparation of various sub-cellular fraction of rat liver

Assay of marker enzymes for

© Nuclei
© Mitochondria

- Cytoplasm
- Fractionation of leaf cell by Differential centrifugation
- Isolation of mitochondria from rat liver/ plant leaves
- Isolation of Chloroplast from plant leaves

Calculate Chlorophyll content

Determine the chlorophyll a / chlorophyll b ratio in C3 and C4 plants

2. Identification of different stages of mitosis and study of morphology of metaphase chromosomes from Onion root meristems
3. Identification of different stages of meiosis from suitable plant material (Onion Buds).

4. Study of mitotic index using onion root tips

References

- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 1- 15
- Standard Methods of Biochemical Analysis, S. K. Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, p 465 471

BC2B002U: Core Course II: Physical aspects of Biochemistry.

Total hours of instruction: 36. Hours/week: 2. Credit: 2

Objectives: Introduce the student to basic concepts of acid and bases and its importance in biological systems, colloidal systems and it applications, measuring concentrations of solutions, understanding the principle of different types of reactions and basics of thermodynamics as applied to biological system

Unit-I: (8h.)

Dissociation of water, ionic product of water, concepts of pH, pOH, simple numerical problems of pH, determination of pH using indicators, pH meter and theoretical calculations. Dissociation of weak acids and electrolytes, Br nsted theory of acids and bases, shapes of titration curve of strong and weak acids and bases. Meaning of Ka and pKa values, Buffers: buffer action, buffers in biological system, Henderson - Hasselbach equation with derivation, simple numerical problems involving application of this equation.

Ref: - Biochemistry: A Students survival Guide by Hiram. F. Gilbert (2002) Publishers: McGraw-Hill ISBN 0-07-135657-6 p 241

Unit II: (8h.)

Meaning of true solution, colloidal solution, and coarse suspension, distinction between lyophilic and lyophobic sols, Fundamental study of Donnan equilibrium- application in biological system, Methods of preparation of colloidal solution, membrane permeability, separation of colloidal solutions, elementary study of charge on colloids, Tyndall effect, application of colloidal chemistry, emulsion and emulsifying agents.

Ref: - Introduction to Biophysics by Pranab Kumar Banerjee (2008) Publishers: S. Chand & Company ltd ISBN: 81-219-3016-2 p 32

Unit III: (8h.)
Meaning of normality, molarity, molality, percentage solution, mole fractions, simple numerical problems from the above, Fundamental principles of diffusion and osmosis, definition of osmotic pressure, isotonic, hypotonic and hypertonic solutions, Biological importance of osmosis, Relationship of osmotic pressure to gas laws, General equation for dilute solutions, influence of ionization and molecular size on osmotic pressure.

Ref: - Introduction to Biophysics by Pranab Kumar Banerjee (2008) Publishers: S. Chand & Company ltd ISBN: 81-219-3016-2 p 21

Unit IV: (4h.)
Classification of isomerism, oxidation reduction reactions, substitution, addition, elimination, condensation and decarboxylation with examples for each, Intra and Intermolecular interactions in biological system: Hydrogen bond, Covalent bond, hydrophobic interaction, disulphide bond, Peptide bonds, glycosidic bond, Phosphodiester linkage, Watson- Crick base pairings, Vander Wall﷽s force.

Ref: - Introduction to Biophysics by Pranab Kumar Banerjee (2008) Publishers: S. Chand & Company ltd ISBN: 81-219-3016-2 p 74

Unit V: (8h.)

Introduction to chemical kinetics, equilibrium reactions, law of mass action, equilibrium constant, definition of catalysis, Basic principles of thermodynamics: free energy, enthalpy, entropy, reversible and irreversible reactions- as applied to biological systems.

Ref: - Biochemistry: A Students survival Guide by Hiram. F. Gilbert (2002) Publishers: McGraw-Hill ISBN 0-07-135657-6 p 261

Ref: - Introduction to Biophysics by Pranab Kumar Banerjee (2008) Publishers: S. Chand & Company ltd ISBN: 81-219-3016-2 p 217

Suggested Readings

- E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974
- Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson
- Michael M. Cox
- Publisher: W. H. Freeman; Fourth Edition edition (April 23, 2004) ISBN-10: 0716743396 ISBN-13: 978-0716743392
- Principles Of Physical Chemistry (2008) by Puri Br, Sharma Lr, Madan S Pathania Vishal PublishingCo, India ISBN: 8188646008ISBN**-13:** 9788188646005, 978-8188646005
- Textbook Of Medical Biochemistry (third Edition) (2001) by S. Ramakrishnan **Publisher:** Orient Longman **ISBN:** 8125020713, **ISBN-13:** 9788125020714, 978-8125020714
- Biochemistry: A Students survival Guide by Hiram. F. Gilbert (2002) Publishers: McGraw-Hill ISBN 0-07-135657-6

BC2B002U: Core Practical II

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objectives: - Resolve quantitative problems concerning the preparation of solutions and buffers. Have a basic understanding of preparing Colloidal gels and to understand the principles underlying membrane potential

1. Preparation of solutions:
   - Percentage solutions
   - Molar solutions
   - Normal solutions
   - Dilution of Stock solutions

2. Standardization of pH meter.
3. Measurements of pH of solutions using pH meters.

4. Preparation of buffers using the Henderson Hasselbach equation

5. Preparation of Colloidal solutions:
   Preparation of Colloidal solution of Prussian blue and Arsenious Sulfide by double decomposition
   Preparation of Colloidal Ferric Hydroxide by Hydrolysis
   Preparation of emulsoid solutions

6. Experiments with colloidal gels
   Dialysis (Diffusion through membranes)
   Diffusion through gels
   Mutual Precipitation of Colloids
   Precipitation of Colloids by salts
   Adsorption by Charcoal
7. Experiments on Donnan Equillibrium
   Demonstration of Donnan equilibrium using a membrane
   Demonstration of Donnan equilibrium without using a membrane

Reference:

- Hawk&#65533;s Physiological Chemistry, Bernard L. Oser (ed) TATA McGRAW Hill Publishing Company LTD, New Delhi, p 10- 15.
- Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi ISBN 81-88237-41-8, p 13- 17, p 39 - 43
- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9 p 1- 15

BC3B003U: Core Course III: Methods in Biochemistry

Total hours of instruction: 54. Hours/week: 3. Credit: 3

Objective: Explain the basis and general methodology of the molecular separation techniques specified in the course. Explain the application of these techniques to the separation of mixtures with known compositions. Explain the basis and general methodology of the molecular characterization techniques and to introduce students to basics of Bioinformatics and Research methodology

Unit I: (14 h.)

Research methodology and Biostatistics: Methodology of scientific research, nature of scientific methods, design of experiments in biochemistry, significance of statistical methods in biological investigations, sampling techniques, statistical evaluation of results, probability theory, random variables and distribution function, point and interval estimation, multiple linear regression, correlation and analysis of variance and covariance, distribution of student's t-test, Chi-square (X^2), correlation coefficient (r), Computer statistical packages for statistical analysis. Introduction to Bioinformatics, biological databases: NCBI, DDBJ, EMBL, PDB, KRGG. Basic Local Alignment search Tool (BLAST)

Ref: -An Introduction to Biostatistics: A Manual for students in Health Sciences by P.Sundar Rao, J.Richard Publishers: Prentice-Hall Pvt Ltd ISBN 81-203-1008-X

Ref: - Introduction to Bioinformatics (2002) by T.K Atwood and D.J Parry- Smith Publisher: Pearson Education Pvt Ltd ISBN 81-7808-507-0 p35

Unit II: (10 h.)

Chromatography: - principle, procedure and application of partition chromatography, adsorption chromatography, and ion exchange chromatography, gel permeation chromatography, affinity chromatography, GLC and HPLC.

Ref: - Introduction to Biophysics by Pranab Kumar Banerjee (2008) Publishers: S. Chand & Company ltd ISBN: 81-219-3016-2 p 183

Unit III: (10h.)

Electrophoresis: - Principle, procedure and application of free flow, zone electrophoresis (Paper electrophoresis, Gel electrophoresis, Native PAGE, SDS-PAGE, AGE). Isoelectricfocussing, High voltage electrophoresis, Pulse field electrophoresis, Immunoelectrophoresis.

Ref: - Introduction to Biophysics by Pranab Kumar Banerjee (2008) Publishers: S. Chand & Company ltd ISBN: 81-219-3016-2 p 197

Unit IV: (10h.)

Methods of tissue homogenization, Salt and organic solvent extraction and fractionation, Dialysis, Reverse dialysis, ultra filtration, lyophilization, Centrifugation: - Principle of sedimentation technique. Different types of centrifuge and rotors, Principle, procedure and application of differential centrifugation, density gradient centrifugation, ultracentrifugation, rate zonal centrifugation, isopycnic centrifugation.

Ref: - Introduction to Biophysics by Pranab Kumar Banerjee (2008) Publishers: S. Chand & Company ltd ISBN: 81-219-3016-2 p 177

Unit V: (10h.)

Colorimetry and Spectrophotometry: - Beer - Lambert's law, UV and visible absorption spectra, molar extinction coefficient and quantitation, Principle of colorimetry and spectrophotometry, Principle of nephelometry, fluorimetry, Atomic absorption and emission spectrophotometer.

Ref: - Introduction to Biophysics by Pranab Kumar Banerjee (2008) Publishers: S. Chand & Company ltd ISBN: 81-219-3016-2 p 166

Suggested Readings

- Physical Biochemistry by David Freifelder Publisher: W.H.Freeman & Co Ltd (September 1976) ISBN-10: 0716705591 ISBN-13: 978-0716705598
- A Biologist's Guide to Principles and Techniques of Practical Biochemistry by BryanL.Williams, KeithWilson Hodder Education, ISBN 071312461X (0-7131-2461-X)
- Principles and Techniques of Practical Biochemistry by Keith M. Wilson, John M. Walker Cambridge University Press, ISBN 0521428092 (0-521-42809-2)
- The Tools of Biochemistry by Cooper, T. G. 1977. Publisher: John Wiley & Sons
- Biophysical Chemistry Principles & Techniques Handbook (2003) by Avinash Upadhyay, Kakoli Upadhyay, Nirmalendu Nath Publisher: Himalaya Publishing House ISBN: 8178665883 ISBN-13: 9788178665887, 978-8178665887
- Research Methodology For Biological Sciences (2006) by Gurumani N Publisher: Mjp Publishers ISBN: 8180940160 ISBN-13: 9788180940163, 978-8180940163
- Instrumental Methods Of Chemical Analysis (2006) by M.s. Yadav Publisher: Campus Books International ISBN: 8187815620 ISBN-13: 9788187815624, 978-8187815624
- Introduction to Bioinformatics (2002) by T.K Atwood and D.J Parry- Smith Publisher: Pearson Education Pvt Ltd ISBN 81-7808-507-0
- Introduction to Biostatistics: A textbook of Biometry (2004) by Pranab Kumar Banerjee Publisher S. Chand Company Ltd New Delhi
- Biostatistics (2005) by P.N. Arora, P.K. Malhan Publishers: Himalaya Publishing house ISBN: 81-8318-298-4
- An Introduction to Biostatistics: A Manual for students in Health Sciences by P.Sundar Rao, J.Richard Publishers: Prentice-Hall Pvt Ltd ISBN 81-203-1008-X

BC3B003U: Core Practical III

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objectives: To make it possible for the student to have a practical understanding of methodology of the molecular separation techniques specified in the course. Formulate the protocol of a spectrometric determination. Calculate quantities and concentrations of substances from the results of spectrometric determinations.

Biochemical separation Techniques

1. Chromatographic techniques

Separation of amino acids and simple sugars by Paper chromatography (Descending or ascending)
Separation of amino acids and lipids by Thin Layer chromatography

Separation of Plant pigments by Column chromatography

2. Centrifugation Technique
   Isolation of crude Cytoplasmic fraction from a biological tissue sample

3. Precipitation Technique
   Ammonium sulfate fractionation of isolated crude cytoplasmic fraction

4. Dialysis of ammonium sulfate fractions

5. Isoelectric Precipitation of Casein

6. Colorimetry and Spectrophotometry techniques

   Verification of Beer Lambert's law.
   Verification of molar extinction coefficient of any known compound.

References

- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 195 – 303

- Standard Methods of Biochemical Analysis, S. K. Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, p 12 - 18

BC4B004U: Core Course IV: Biomolecules

Total hours of instruction: 54. Hours/week: 3. Credit: 3

Objectives: Describe the structural characteristics of the inorganic components of living matter, the different types of simple organic biomolecules, their biologically important derivatives and the structural units of complex biomolecules. Describe the structural characteristics of the different types of complex biomolecules (glycosides, lipids, nucleotides, nucleic acids and proteins) and indicate the constituent units, the links between them, and the conformation and grouping of subunits. Explain the classification criteria and nomenclature of the different types of simple and complex biomolecules, according to their structural characteristics. Formulate the molecular structure of the different types of simple biomolecules. Schematize the molecular structure of the different types of complex biomolecules. Identify from a group of molecular formulae, diagrams or models those which correspond to the different types of biomolecules. Explain the physicochemical properties of the different types of biologically important biomolecules.

Unit I: (14 h.)
Carbohydrates: Classification, monosaccharides, D and L designation, open chain and cyclic structures, epimers and anomers, mutarotation, reactions of carbohydrates (due to functional groups - hydroxyl, aldehyde and ketone). Reaction of sugars: Reactions of aldehyde and keto group, action of acids and alkali on sugars, reactions of sugars due to hydroxyl group, Amino sugars, Glycosides, Structure and biological importance of disaccharides (sucrose, lactose, maltose, isomaltose, trehalose), trisaccharides (raffinose, melezitose), structural polysaccharides (cellulose, chitin, pectin) and storage polysaccharides (starch, inulin, glycogen), Glycosaminoglycans, Bacterial cell wall polysaccharides, Outlines of glycoproteins, glycolipids and blood group substances.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 73, 91, 100, 114

Unit II: (10h.)

Lipids: Definition, basic ideas about the biochemical functions of lipids, Classification of lipids with examples, classification of fatty acids, physical and chemical properties of fatty acids-saponification number, acid number and iodine number and their application. Essential and non-essential fatty acids with examples, Prostaglandins- structure and biological role of PGD2, PGE2 and PGF2 α. Lipoproteins: Types and functions. Compound lipids: storage and membrane lipids. Structure and functions of phospholipids and glycolipids, Steroids: Strucutre of steroid nucleus, cholesterol, ergosterol, stigmasterol, calciferol, Biomembranes: Behavior of amphipathic lipids in water- formation of micelles, bilayers, vesicles, liposomes.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 230, 244, 269

Unit III: (14 h.)
Amino acids: Definition, stereoisomerism, structure of 20 ﷺStandard amino acidsﷺ - single letter abbreviations of amino acids, classification of amino acids based on charge and polarity, general reactions of amino acids- side chain, carboxyl and amino group- essential and non essential amino acids, ionization of amino acids. Titration curve of glycine and p*K* values
Non-standard amino acids, Amino acid derivatives of biological significance, Peptides: Formation of peptide bond, structure of glutathione, oxytocin and vasopressin. Proteins: Classification based on solubility, shape and function. Determination of amino acid composition of proteins, General properties of proteins, denaturation and renaturation of proteins, Structural organization of proteins- primary, secondary, tertiary and quaternary structures (E.g. Hemoglobin and Myoglobin), forces stabilizing the structure of protein, Outlines of protein sequencing.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 132, 204, 214

Unit IV: (8h.)
Nucleic acids: Nature of nucleic acids, Structure of purines and pyrimidines, nucleosides, nucleotides, Stability and formation of Phosphodiester linkages, Effect of acids, alkali and nucleases on DNA and RNA, Structure of Nucleic acids- Watson-Crick DNA double helix structure, introduction to circular DNA, super coiling, helix to random coil transition, denaturation of nucleic acids- hyperchromic effect, *T*m-values and their significance, Reassociation kinetics, cot curves and their significance, Types of RNA and DNA, Unusual bases in nucleic acids. DNA sequencing: Sanger and Dideoxy methods.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 280

Unit V: (4h.)
Vitamins: Definition, classification- fat-soluble and water-soluble: sources, chemical nature (without structure), and functions of vitamins. Minerals: requirements, macro and micro minerals (source and functions).

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 959, 988

Suggested Readings

- Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson
- Michael M. Cox
- Publisher: W. H. Freeman; Fourth Edition edition (April 23, 2004) ISBN-10: 0716743396 ISBN-13: 978-0716743392
- E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974
- Biochemistry [with Cdrom] (2004) by Donald Voet, Judith G. Voet Publisher: John Wiley & Sons Inc ISBN: 047119350X ISBN-13: 9780471193500, 978-0471193500
- Principles Of Biochemistry (1995) by Geoffrey L Zubay, William W Parson, Dennis E Vance Publisher: Mcgraw-hill Book Company ﷺ Koga ISBN:0697142752
  ISBN-13: 9780697142757, 978-0697142757

- Principles Of Biochemistry, 4/e (2006) by Robert Horton H , Laurence A Moran, Gray Scrimgeour K Publisher: Pearsarson ISBN: 0131977369, ISBN-13:9780131977365, 978-0131977365
- Biochemistry 6th Edition (2007) by Jeremy M.berg John L.tymoczko Lubert Stryer Publisher: B.i.publicationsPvt.Ltd ISBN:071676766X ISBN-13: 9780716767664, 978-716767664
- Biochemistry (2008) by Rastogi Publisher: Mcgraw Hill ISBN:0070527954 ISBN-13: 9780070527959, 978-0070527959
- Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7

BC4B004U: Core Practicals IV

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objectives: This course aims to provide the students with an opportunity to develop their qualitative analytical skills. It is expected that the student on completion of this course have a sound knowledge on basic protocols for identification of biomolecules.

1. Reactions of Carbohydrates, Amino acids, Proteins and Lipids

A. Carbohydrates: (Glucose, fructose, Galactose, Xylose, Maltose, Lactose, Sucrose, Starch, dextrin, Glycogen maybe given for analysis).
Molisch's test, Iodine test, Test for reducing sugars (Fehling's test, Benedict's test, Barfoed's test), Seliwanoff's test, Bial's test, Mucic acid test, Acid hydrolysis of Sucrose, Osazone test.
B. Amino acids: (tyrosine, tryptophan, cysteine, cystine, methionine, arginine, proline, histidine may be given for analysis)
Ninhydrin test, Xanthoproteic test, Istatin test, Pauly's diazo test, sakaguchi test, Ehrlich's test, Sodium nitroprusside test, Millon's test, Sullivan's test.
C. Proteins: (Casein, Albumin, Gelatin, peptone may be given for analysis).
Biuret test, Ammonium sulfate precipitation test, Sulphosalicylic acid test, Heat coagulation test.
D. Lipids: Fats- tristearin, Fatty acids- palmitic acid, stearic acid, oleic acid, Glycerol, Steroids, cholesterol
Solubility in Organic solvents, saponification test, Acrolein test, Test for unsaturation: with bromine water or dilute potassium permanganate or Hubl's iodine test, salkowski test, Zak's test.

2. Identification of Monosaccharide, Disaccharide, polysaccharide from a mixture following a systematic scheme of analysis (only two component mixture of above mentioned carbohydrates to be given).

3. Identification of amino acids and proteins following a systematic scheme for analysis (single components only need be given)

4. Identification of lipids following a systematic scheme for analysis (single components only need be given)

Reference:

- Hawk's Physiological Chemistry, Bernard L. Oser (ed) TATA McGRAW Hill Publishing Company LTD, New Delhi, p 60 – 127, 1317- 1334
- Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi ISBN 81-88237-41-8, p 13- 17, p 49 - 72
- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9 p 15- 23, 33- 35, 50 -57.
- Practical Biochemistry, R.C. Gupta & S. Bhargava (eds) CBS Publishers and Distributors, New Delhi, ISBN 81-239-0124-0 p 9 - 27

BC5B005U: Core Course V: Physiological Aspects of Biochemistry

Total hours of instruction: 54. Hours/week: 3. Credit: 3

Objectives: Discuss the physiological functions of the biological system. The aim here is to provide an overall, introductory view on some specialized tissues.

Unit I: (8 h.)

Digestion and absorption: Digestion and absorption of carbohydrates, proteins, and lipids. Mechanism of gastric HCl formation, Composition and function of bile, role of bile salts in Lipid digestion and absorption. Role of γ-glutamyl cycle in amino acid absorption.

Ref: - Biochemistry by Debajyoti das. Academic publishers. Kolkata.p 323 – 349
Ref: - Text book of Biochemistry by Edward Staunton West, Wilbert R Todd, Howard S Manson and John T Van Bruggen. Macmillan Publishing Company Inc. New York.
p 494 – 535.

Unit II: (12 h.)

Biochemistry of Blood: Constituents of blood, types of cells, components of plasma, types of plasma proteins and function, Mechanism of blood clotting (intrinsic and extrinsic pathway) Clotting factors, anticoagulants, fibrinolysis, Structure and function of hemoglobin, Transport of oxygen and carbon dioxide in blood, carbonic anhydrase, chloride shift, oxygen dissociation curve and Bohr effect, Variants of hemoglobin, Sickle cell Hemoglobin, thalassemia, Buffer systems of blood, acid – base balance, acidosis and alkalosis role of lungs in regulation of pH.

Ref: - Biochemistry by Debajyoti das. Academic publishers. Kolkata.p 350 – 390
Ref: - Text book of Biochemistry by Edward Staunton West, Wilbert R Todd, Howard S Manson and John T Van Bruggen. Macmillan Publishing Company Inc. New York.
p 550 – 629.

Unit III: (10 h.)

Structure of nephrons, renal excretory mechanism, composition of urine, regulation of water and electrolyte balance, Role of aldosterone and antidiuretic hormones and mechanism of urine formation, renal regulation of pH.

Ref: - Biochemistry by Debajyoti das. Academic publishers. Kolkata.p 614 – 635
Ref: - Text book of Biochemistry by Edward Staunton West, Wilbert R Todd, Howard S Manson and John T Van Bruggen. Macmillan Publishing Company Inc. New York.
p 665 – 731.

Unit IV: (12 h.)

Biochemistry of Specialized tissues: Muscle- types of muscles, muscle proteins, organization of contractile protein and mechanisms of muscle contraction Sources of energy for muscle contraction.
Neurons- structure, mechanism of nerve impulse transmission, neurotransmitters, acetylcholine, GABA, serotonin, dopamine
Bone- Role of calcium, phosphorus, vitamin D and hormones in bone metabolism.

Ref: - Text Book of Biochemistry by D M Vasudevan and Sreekumari S. Jaypee Brothers, Medical Publishers Pvt Ltd. New Delhi. p 467 – 475.
Ref: - Biochemistry by Debajyoti das. Academic publishers. Kolkata.p 636 – 660
Ref: - Illustrated Medical Biochemistry by S M Raja and Bindu Madak. Jaypee Brothers Medical Publishers Pvt Ltd.New Delhi. p 221 – 231

Unit V: (12 h.)

Endocrinology**:** Organization of endocrine system. Classification of hormones and hormone action- Peptide and amino acid derived hormones and Steroid and thyroid hormones. Mechanism of action of hormones, Brief study of the site of biosynthesis and major physiological functions of insulin, glucagon, epinephrine, thyroxine, glucocorticoids, mineralocorticoids, androgen, esterogen, growth hormone, corticotropic

hormone, thyroid stimulating hormone, gonadotropic hormone, vasopressin, oxytocin, parathyroid hormone and calcitonin. Nerve growth factor, Insulin growth factor, epidermal growth factor, gastrointestinal hormones.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 835

Suggested Readings

- Textbook Of Medical Physiology, 11/e With Student Consult Access (2005) by Arthur C Guyton, John E Hall Publisher**:** Else ISBN: 8181479203 ISBN-13: 9788181479204**,** 978-8181479204
- Human Physiology (2001) by Bipin Kumar Publisher: Campus Books International ISBN: 8187815604 ISBN-13: 9788187815600, 978-8187815600
- Human Physiology (2001) by K.c. Sawant Publisher: Dominant Publishers & Distributors
- ISBN: 8178880202 ISBN-13: 9788178880204, 978-8178880204
- Human Physiology (2001) by Andrew Davies, Asa Gh Blakeley, Cecil Kidd Publisher**:** Churchill Livingstone ISBN**:**0443046549, ISBN-13**:** 9780443046544, 978-0443046544
- Principles Of Biochemistry, 6e (1959) by Abraham White, Philip Handler Publisher: Tata Mcgraw-hill Publishing Company Limited ISBN:0070590494 ISBN-13: 9780070590496, 978-0070590496

BC5B006U: Core Course VI: Immunology and Immunological Techniques

Total hours of instruction: 54. Hours/week: 3. Credit: 3

Objectives: To introduce the students in understanding the basis of the science of immunology at the molecular, cellular, and whole-organism levels

Unit I: (8 h.)

Organs of Immune system: Primary and secondary lymphoid organs, Cells of Immune system- lymphoid cells, stem cells, B and T lymphocytes, Null cells, Mononucelar cells, granulocytic cells.

Ref: - Elements Of Immunology by S C Rastogi (2006) **Publisher:** Cbs Publishers & Distributors ISBN**:** 8123907737 **ISBN-13:** 9788123907734**,** 978-8123907734

Unit II: (10 h.)

Immunity: Innate immunity (Non specific) - Anatomic barriers, Physical barrier, Phagocytic, Inflammatory. Adaptive (Specific) Immunity- Humoral and cell mediated immune responses, Recognition of antigens by B and T lymphocytes. Processing and presentation of antigens, Clonal selection of lymphocytes, Cellular interaction for generation of humoral and cell mediated response.

Ref: - Elements Of Immunology by S C Rastogi (2006) **Publisher:** Cbs Publishers & Distributors ISBN**:** 8123907737 **ISBN-13:** 9788123907734**,** 978-8123907734

Unit III: (12 h.)

Antigens: Factors that influence immunogenicity, epitopes, haptens, Immunoglobulins- Structure of immunoglobulins, Classes of immunoglobulins and their functions. Antigenic determinants of immunoglobulins, Monoclonal antibody preparation and application Complement system: The function of complement, complement activation. Major histocompatibility (elementary study), Transplantation immunology.

Ref: - Elements Of Immunology by S C Rastogi (2006) **Publisher:** Cbs Publishers & Distributors ISBN**:** 8123907737 **ISBN-13:** 9788123907734**,** 978-8123907734

Unit IV: (12 h.)

Antigen-antibody interactions: Precipitation reaction, agglutination, ELISA, RIA, Immunoprecipitation, Immunofluorescence, T- cell receptors, maturation, activation and differentiation, B- Cell receptors, maturation, activation and proliferation, Cytokine- structure and function.

Ref: - Immunology by Roitt Publisher: Mosby ISBN: 0702025496 ISBN-13: 9780702025495**,** 978-0702025495

Unit V: (12 h.)

Vaccine: Active and passive immunization, types of vaccines. Autoimmune diseases- Definition, Types of immune diseases like systemic lupus erythromatus, Multiple sclerosis, Rheumatoid arthritis, scleroderma, Myasthenia garavis, Hyper-sensitivity and allergy.

Ref: - Immunology by Roitt Publisher: Mosby ISBN: 0702025496 ISBN-13: 9780702025495**,** 978-0702025495

Suggested Readings:

- Immunology: An Introduction by Ian R Tizard (2006) Publisher: Cengage Learning (Thompson) ISBN: 8131500039, ISBN-13: 9788131500033, 978-8131500033
- Immunology and Immunotechnology by Chakravarty (2006) Publisher: Oxford University Press N Delhi ISBN: 0195676882, ISBN-13: 9780195676884**,** 978-0195676884
- Kuby Immunology by Thomas J. Kindt (2006) Publisher: W H Freeman & Co ISBN: 0716785900, ISBN-13: 9780716785903, 978-0716785903
- Elements of Immunology (2009) by Khan Publisher: Dorling Kindersley (India) Pvt Ltd ISBN: 8131711587 ISBN-13: 9788131711583**,** 978-8131711583
- Immunology by K.R. Joshi **(**2007) Publisher: Agrobios (India) ISBN**:** 8177541749, ISBN-13: 9788177541748**,** 978-8177541748
- Basic Immunology, 3ed by: Abbas Publisher: Elser ISBN: 8131217477, ISBN-13: 9788131217474**,** 978-8131217474
- Immunology by P.R. Yadav **(**2004) Publisher: Discovery Publishing House ISBN: 8171418570, ISBN-13: 9788171418572**,** 978-8171418572
- Immunology by David A. Marcus, Richard A. Goldsby, Barbara A. Osborne **(**2003) Publisher: W.h. Freeman & Company ISBN: 0716749475 ISBN-13: 9780716749479**,** 978-0716749479
- Immunology by Roitt Publisher: Mosby ISBN: 0702025496 ISBN-13: 9780702025495**,** 978-0702025495

BC5B007U: Core Course VII: Enzymology and Enzyme Technology

Total hours of instruction: 54. Hours/week: 3. Credit: 3

Objectives: This course aims to describe the structural characteristics of enzymes; explain their functional properties and their role in control of metabolism and industrial application of enzymes.

Unit I: (10hr.)

Introduction to enzymes: Holoenzyme, apoenzyme, and prosthetic group. Interaction between enzyme and substrate- lock and key model, induced fit model, Features of active site, activation energy, enzyme specificity and types Enzyme Commission system of classification and nomenclature of enzymes (Class and subclass with one example) Ribozymes, Abzymes. Coenzymes and their functions - NAD, $NADP^+$, FAD, FMN, lipoic acid, TPP, pyridoxal phosphate, biotin and cyanocobalamin.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 269

Unit II: (8 hr.)

Nature of non-enzymatic and enzymatic catalysis, Measurement and expression of enzyme activity, enzyme assays. Definition of IU, katals, enzyme turnover number and specific activity, Elementary study isolation of enzymes and the criteria of purity.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 349,

Unit III: (13 hr.)

Enzyme kinetics: Importance, order of reaction, study of the factors affecting the velocity of enzyme catalyzed reaction- enzyme concentration, temperature, pH, substrate concentration, inhibitors and activators (explanation with graphical representation). Derivation of Michaelis -Menten equation and Km value determination and its significance, Definition of V_{max} value of enzyme and its significance, Lineweaver- Burk plot (Only for single substrate enzyme catalyzed reaction), Enzyme inhibition: Reversible and irreversible examples. Reversible- competitive, noncompetitive and uncompetitive inhibition- explanation of inhibition types with double reciprocal plot and examples of each type of enzyme inhibition.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 372, 384, 385,

Unit IV: (13 hr.)

Enzyme regulation – covalently modulated enzymes with examples of adenylation and phosphorylation and allosteric regulation- example Aspartate trascarbamoylase, Isoenzymes- Lactate dehydrogenase and creatine phosphokinase, Zymogen form of enzyme and zymogen activation, Multienzyme complexes and their role in regulation of metabolic pathways.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 397

Unit V: (10 hr.)

Immobilization of enzymes, methods of immobilization, Industrial uses of enzymes: production of glucose from starch, cellulose and dextrans, use of lactase in diary industry, production of glucose fructose syrup from sucrose, use of proteases in food, leather and detergent industry. Diagnostic and therapeutic enzymes (brief study of name of enzyme and role in diagnosis and therapy)

Suggested Readings

- Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins by Nicholas C. Price, Lewis Stevens, and Lewis Stevens (2000) Publisher: Oxford University Press, USA ISBN: 019850229X ISBN-13: 9780198502296**,** 978-0198502296
- Enzyme Kinetics: A Modern Approach Book: Enzyme Kinetics: A Modern Approach by Alejandro G. Marangoni (2003) Publisher: Wiley-Interscience ISBN: 0471159859 ISBN-13: 9780471159858**,** 978-0471159858
- Enzyme Kinetics and Mechanisms by Taylor Publisher: Spring ISBN: 8184890478 ISBN-13: 9788184890471**,** 978-8184890471
- Enzyme Mechanism by P.K. Shivraj Kumar **(**2007) Publisher: RBSA Publishers ISBN: 8176114235 ISBN-13: 9788176114233**,** 978-8176114233
- Enzymes and Enzyme Technology by Kumar **(**2009) Anshan Pub ISBN: 1905740875, ISBN-13: 9781905740871**, 978**-1905740871
- Enzymes in Industry: Production And Applications by Aehle W **(**2007) Publisher**:** John Wiley & Sons Inc ISBN: 3527316892 ISBN-13: 9783527316892**,** 978-3527316892
- Enzymes: Biochemistry, Biotechnology, Clinical Chemistry (second Edition) by Trevor Palmer, Philip Bonner **(**2007) Publisher: Horwood Publishing Limited ISBN: 1904275273 ISBN-13: 9781904275275**,** 978-1904275275

BC5B008U: Core Course VIII: Metabolism and Bioenergetics

Total hours of instruction: 54. Hours/week: 3. Credit: 3

Objectives: Explain the general principals of cellular energy metabolism. Explain and schematize the oxidative pathways of carbohydrates, Lipids, Proteins & Nucleic acids. Explain and schematize the final

mitochondrial oxidative pathways: oxidative tricarboxylic cycle and mitochondrial respiratory chain, as well as its coupling to ATP synthesis.

Unit I: (5h.)
Bioenergetics: Laws of thermodynamics- Role of high-energy phosphates in energy transfer, free energy concept, Biological oxidation, redox potential, phosphate potential, coupled reactions. General features of metabolism: use of intact organisms, bacterial mutants, tissue slices and radioactive isotopes.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 434

Unit II: (16 h.)
Carbohydrate metabolism: (Reaction sequence with structure, name of enzymes and coenzymes involved expected) Glycolysis, oxidation of pyruvate, fate of pyruvate in alcoholic fermentation, TCA cycle, metabolism of glycogen, gluconeogenesis, pentose phosphate pathway, C_3, C4 and CAM pathway, glyoxylate pathway, Mitochondrial electron transport, oxidative phosphorylation, inhibitors. Regulation of committed step in each pathway.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 458,481,522,

Unit III: (12 h.)
Metabolism of lipids: Biosynthesis of fatty acids, Fatty acid elongation. Difference in fatty acid synthesis in plants and animals, Brief mention of α- ω- oxidation of fatty acids, detailed study on β- oxidation of palmitic acid and its energy balance sheet, Metabolism of ketone bodies, Cholesterol synthesis (structure not needed) and significance, Synthesis of steroid hormones from cholesterol, Regulation of committed step in each pathway.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 564, 594

Unit IV: (12 h.)
Metabolism of proteins: Protein-turn over, proteolytic enzymes. trasamination, oxidative deamination, reductive amination, non-oxidative deamination and decarboxylation of amino acids Urea cycle and GS/GOGAT pathway. Brief outline of metabolism of aromatic amino acids (reaction sequences with structures) metabolic fate of amino acids- glucogenic, ketogenic and gluco-ketogenic, biosynthesis of amino acids, Regulation of committed step in each pathway.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 641, 687

Unit V: (9 h.)

Metabolism of nucleotide: Biosynthesis of purine and pyrimidine nucleotides *de novo* and salvage pathway (no structure required) end products of purine and pyrimidine metabolism. Regulation of committed step in each pathway.

Ref: - Biochemistry (2008) by Rastogi Publisher: Mcgraw Hill ISBN:0070527954 ISBN-13: 9780070527959, 978-0070527959

Suggested Readings

- Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson
- Michael M. Cox
- Publisher: W. H. Freeman; Fourth Edition edition (April 23, 2004) ISBN-10: 0716743396 ISBN-13: 978-0716743392
- E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974
- Biochemistry [with Cdrom] (2004) by Donald Voet, Judith G. Voet Publisher: John Wiley & Sons Inc ISBN: 047119350X ISBN-13: 9780471193500, 978-0471193500
- Principles Of Biochemistry (1995) by Geoffrey L Zubay, William W Parson, Dennis E Vance Publisher: Mcgraw-hill Book Company – Koga ISBN:0697142752
  ISBN-13: 9780697142757, 978-0697142757
- Principles Of Biochemistry, 4/e (2006) by Robert Horton H , Laurence A Moran, Gray Scrimgeour K Publisher: Pearsarson ISBN: 0131977369, ISBN-13:9780131977365, 978-0131977365
- Biochemistry 6th Edition (2007) by Jeremy M.berg John L.tymoczko Lubert Stryer Publisher: B.i.publicationsPvt.Ltd ISBN:071676766X ISBN-13: 9780716767664, 978-716767664
- Biochemistry (2008) by Rastogi Publisher: Mcgraw Hill ISBN:0070527954 ISBN-13: 9780070527959, 978-0070527959

BC5B005U: Core Practicals V:

Total hours of instruction: 36. **Hours/week: 2.** **Credit: 1**

Objectives: This Practical course introduces the students to analysis of various important body fluids

1. Experiments on saliva

- Digestion of starch by salivary amylase
- Preparation of Mucin

2. Preparation of Artifical Gastric juice

- From Commercial Pepsin

3. Preparation of Pepsinogen Extract

4. Product of Gastric Digestion

5. Experiments on Gastric Digestion

- Influence of Different Temperature

- Optimum acidity of Peptic Digestion
- Differentiation between Pepsin and Pepsinogen
- Quantitative determination of Rennin

6. Determination of pepsin activity with Albumin Substrate

7. Determination of tryptic activity with Casein Substrate

8. Detection of Occult blood

Reference:

- Hawk's Physiological Chemistry, Bernard L. Oser (ed) TATA McGRAW Hill Publishing Company LTD, New Delhi, p 459- 487

- Practical Clinical Chemistry, Harold Varley, CBS Publishers and Distributors, New Delhi, p327 – 348

BC5B006U: Core Practicals VI:

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objectives: This Practical course aims to introduce the students to basic protocols in Immunology

Commercially available Teaching Kits can be used for Demonstrations of the Practicals of this paper wherever necessary:

1. Demonstration of antigen – antibody interactions: Ouchterlony technique

2. Demonstration of Enzyme linked immunosorbant assay (ELISA): antibody capture assay

3. Purification of bovine serum immunoglobulin G (IgG) fraction by ammonium sulfate precipitation (micro method)

4. Haemagglutination

- Direct agglutination reaction: determination of human blood group antigens
- Indirect (Passive) Haemagglutination test

5. Coating of Red Blood Cells with Antigens

- Direct adsorption of Antigens by Red Cells
- Tanned Cells technique for attachment of Antigens

6. Bacterial Agglutination

- Widal test

References

- Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi ISBN 81-88237-41-8, p 245- 261

- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 339- 389

- A Handbook of Practical and Clinical Immunology 2nd ed G.P. Talwar and S.K. Gupta (eds) (2005) Publishers: CBS Publishers and distributors ISBN: 81-239-0017-1, p195 -207

BC5B007U: Core Practicals VII:

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objectives: The objective here is to make the students understand the basic steps involved in extraction and determination of enzymatic activities. Calculate enzymatic activities from experimental data

1. Extraction of enzymes:

- Acid phosphatase from Fresh Potato (*Solanum tuberosum*)
- β- amylase from Sweet potato (*Ipomoea batates*)
- Catalase from Bovine /Porcine liver
- Urease from Jack bean (*Canavalia ensiformis*)
- Phytase from Seeds

2. Enzyme Assay: Enzyme extracted from above source can be used for the assay

- Acid phosphatase
- β- amylase
- Catalase
- Urease from Jack bean
- Phytase

3. Effect of substrate Concentration on velocity of Enzyme catalyzed reaction:

- Determination of K_M and V_{max} using Michaelis- Menten Curve for amylase

References

- Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi ISBN 81-88237-41-8, p 173- 187

- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 110 – 155

- Standard Methods of Biochemical Analysis, S. K. Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, p 184 – 255

BC5B008U: Core Practicals VIII:

Total hours of instruction: 54. Hours/week: 3. Credit: 1

Objectives: To introduce the students to protocols of spectrophotometric determination. Calculate quantities and concentrations of biomolecules from standard curves

A. Separation and Estimation of Carbohydrates: (Any 5 experiments to be done)

1. Isolation and determination of Liver Glycogen
2. Isolation and determination of Starch in Plant Tissue
3. Estimation of Cellulose
4. Estimation of crude fiber
5. Determination of total sugars by ferricyanide method (Colorimetric)
6. Quantitation of total sugars by anthrone method
7. Determination of reducing sugars by Nelson & Somogyi's method
8. Estimation of reducing sugars by dinitrosalicylate method
9. Determination of fructose by Roe's resorcinol method

B. Separation and Estimation of Lipids: (Any 5 experiments to be done)

1. Extraction and estimation of total lipid content from a biological tissue sample
2. Separation and identification of various lipids by Column Chromatography
3. Separation of various components in different lipid fractions by thin layer chromatography
4. Quantitative estimation of different lipid fractions separated by thin layer Chromatography
5. Estimation of Cholesterol by Zak's method
6. Determination of acid value of fats
7. Determination of saponification value of fats
8. Determination of iodine number of oils
9. Determination of peroxide value of oils

C. Separation and Estimation of Proteins and Amino acids: (Any 4 experiments to be done)

1. Determination of Crude protein by micro- Kjeldahl's method
2. Estimation of protein by Lowry's method
3. Determination of protein by Biuret method
4. Determination of free amino acid content in germinating seeds by Ninhydrin method
5. Determination of tyrosine by nitrosonapthol method
6. Estimation of tryptophan by Spies and Chamber's method

D. Separation and Estimation of Nucleic acids (All 3 experiments need to be done)

1. Extraction of total nucleic acid from plant tissue
2. Estimation of DNA by Diphenylamine method
3. Determination of RNA by orcinol method

E. Separation and Estimation of Minerals and Vitamins (Any 4 experiments to be done)

1. Preparation of biological sample for mineral analysis by ashing method
2. Wet digestion procedure of sample preparation for mineral analysis
3. Determination of Phosphorus content in plant material (Colorimetric method)
4. Colorimetric estimation of iron in foodstuffs by ά ά dipyridyl method
5. Estimation of β- carotene in carrots
6. Quantitative determination of thiamine in cereals and food
7. Estimation of ascorbic acid in Lemon juice

References

- Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi ISBN 81-88237-41-8, p 81- 126
- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 15 – 109
- Standard Methods of Biochemical Analysis, S. K. Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, p 49- 181, p 269- 285

BC6B009U: Core Course IX: Genetics and Molecular Biology

Total hours of instruction: 54. Hours/week: 3. Credit: 3

Objectives: Explain the molecular bases of mechanisms of transmission, recombination and protection of genetic information. Describe the gene structure and gene expression mechanism in eukaryotes: transcription, posttranscriptional processes and translation & Protein degradation

Unit I: (15h.)

Mendel's laws of inheritance, gene interaction, Dominance relationship-complete, incomplete and co-dominance, multiple alleles, linkage, Chromosomal aberrations: Monosomy, trisomy. Translocations, inversions, duplications, deletions.

Ref: - Cell biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. Verma and V. K. Agarwal (2008) Publisher: S. Chand & Company Ltd ISBN: 81-219-2442-1 p 22

Unit II: (10 h.)

Linkage, crossing over, Genetic and cytological mapping of chromosome, sex linked inheritance, determination of sex and sex differentiation, genetic recombination and gene transfer.

Ref: - Cell biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. Verma and V. K. Agarwal (2008) Publisher: S. Chand & Company Ltd ISBN: 81-219-2442-1 p 84, 93, 106, 134, 145,

151

Unit III: (13h.)

Identification of genetic materials, Chemical nature of gene, central dogma of molecular biology, C- value paradox, chromatin organization, Meselson and Stahl experiment, DNA replication in prokaryotes, Mutation and its types, Mutagens- Physical and chemical, Mutagenesis, DNA damage and repair.

Ref: - Cell biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. Verma and V. K. Agarwal (2008) Publisher: S. Chand & Company Ltd ISBN: 81-219-2442-1 p 9, 16, 27, 201

Unit IV: (16 h.)

Transcription in prokaryotes and posttranscriptional modifications, Genetic code and wobble hypothesis, Reverse transcription, Translation in prokaryotes, Posttranslational modifications. Inhibitors of protein synthesis.

Ref: - Cell biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. Verma and V. K. Agarwal (2008) Publisher: S. Chand & Company Ltd ISBN: 81-219-2442-1 p 44, 66, 75

Unit V: (18h.)

Regulation of gene expression in prokaryotes, Operon concept, Lac operon, tryptophan operon, Introduction to recombinant DNA technology: Vectors- plasmids, cosmids, phages, restriction endonucleases Polymerase chain reaction, DNA finger-printing, blotting techniques, Application of genetic engineering (Brief study).

Ref: - Cell biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. Verma and V. K. Agarwal (2008) Publisher: S. Chand & Company Ltd ISBN: 81-219-2442-1
p 91, 110

Suggested Readings

- Genes IX by Benjamin Lewin (2008) Publisher: J&b ISBN:0763752223 ISBN-13: 9780763752224, 978-0763752224
- Molecular Biology Of The Gene 5/e (s) by James D Watson, Tania A Baker, Stephen P Bell (2008) Publisher: Dorling Kindersley (India) Pvt Ltd ISBN: 8177581813
  ISBN-13: 9788177581812, 978-8177581812
- Cell and Molecular Biology, 3e (2003) by Karp Publisher: Jw
  ISBN: 0471268909 ISBN-13: 9780471268901, 978-0471268901
- Molecular Cell Biology (2002) by H.S. Bhamrah Publisher: Anmol Publications ISBN: 8126111429 ISBN-13: 9788126111428, 978-8126111428

- Cell and Molecular Biology by S. Sundara Rajan (2003) Publisher: Anmol Publications ISBN: 8126113553 ISBN-13: 9788126113552, 978-8126113552

BC6B010U: Core course X: Clinical Biochemistry

Total hours of instruction: 54. Hours/week: 3. Credit: 3

Objective: To provide an understanding of future advances in the molecular bases of physiology, physiopathology, diagnostics, therapeutics.

Unit I: (8 h.)

Sample collection and preservation Collection and preservation procedures of blood, plasma, serum, cerebrospinal fluid, urine, faeces, pleural fluid, peritoneal fluid and semen, Analysis of urine: Normal and abnormal constituents, cerebrospinal fluid analysis, Principle of estimation of semen fructose and acid phosphatase.

Ref: - Clinical Biochemistry Principles and Practices by Praful B Godkar, Bhalani publishing house. Bombay. India. p 87- 93
Ref: - Text Book of Biochemistry by D M Vasudevan and Sreekumari S. Jaypee Brothers, Medical Publishers Pvt Ltd. New Delhi. p 512 - 516.
Ref: - Text book of Medical Biochemistry by M.N. Chatterjee and Rana Shinde, Jaypee Brothers, Medical Publishers Pvt Ltd. New Delhi. p 952 - 987.

Unit II: (14h.)

Blood analysis and Hematology: Principles of estimation, normal values and clinical significance of the following parameters of blood -glucose, glycosylated hemoglobin, GTT, insulin levels, uric acid, lipid profiles, acid phosphatase, creatine phosphokinase, Na^+, K^+, Cl^- and phosphate. Principles of determination, clinical significance of the following parameters- Total count, Differential count, Erythrocyte sedimentation rate, packed cell volume and prothrombin time. Brief study of blood groups, anticoagulants, storage and transfusion of blood.

Ref: - Text book of Medical Biochemistry by M.N. Chatterjee and Rana Shinde, Jaypee Brothers, Medical Publishers Pvt Ltd. New Delhi. p 284 - 322
Ref: - Clinical Biochemistry Principles and Practices by Praful B Godkar, Bhalani publishing house. Bombay. India. p 115, 110, 111 - 114

Unit III: (18 h.)

Organ function tests: Function of liver, Biochemical mechanism of detoxification with examples. Principles of the following test of liver function and the interpretation of the results- Total protein, albumin, globulin, albumin ⁄ globulin ratio, Total and conjugated bilirubin, AST, ALT, alkaline phosphate, Thyroid function test: T3, T4, TSH, Renal function tests: Urea, creatinine, urea clearance test, creatinine clearance test.

Ref: - Text book of Medical Biochemistry by M.N. Chatterjee and Rana Shinde, Jaypee Brothers, Medical Publishers Pvt Ltd. New Delhi. p 168 - 202.

Ref: - Text Book of Biochemistry by D M Vasudevan and Sreekumari S. Jaypee Brothers, Medical Publishers Pvt Ltd. New Delhi. p 517 - 525.
Ref: - Clinical Biochemistry Principles and Practices by Praful B Godkar, Bhalani publishing house. Bombay. India. p 87- 93

Unit IV: (4h.)

Clinical correlation of biochemical parameters analyzed in blood analysis, Organ function tests (liver, kidney, and thyroid).

Ref: - Text book of Medical Biochemistry by M.N. Chatterjee and Rana Shinde, Jaypee Brothers, Medical Publishers Pvt Ltd. New Delhi. p 168 - 202.
Ref: - Text Book of Biochemistry by D M Vasudevan and Sreekumari S. Jaypee Brothers, Medical Publishers Pvt Ltd. New Delhi. p 517 - 525.
Ref: - Clinical Biochemistry Principles and Practices by Praful B Godkar, Bhalani publishing house. Bombay. India. p 87- 93

Unit V: (10 h.)

Nutritional and hormonal disorders, Obesity, Starvation, PCM, pellagra, beriberi, scurvy, deficiency of fat soluble vitamins, Hypervitaminosis, Disturbances in metabolism of trace elements - iron, iodine, copper and fluorine. Diabetes mellitus, GTT, hyperinsulinism and hypoglycemia.

Ref: - Clinical Biochemistry Principles and Practices by Praful B Godkar, Bhalani publishing house. Bombay. India. p 258 – 271, 233 – 251, 92 – 117.
Ref: - Text Book of Biochemistry by D M Vasudevan and Sreekumari S. Jaypee Brothers, Medical Publishers Pvt Ltd. New Delhi. p 428 – 451, 480 – 484, 537 - 549.
Ref: - Text book of Medical Biochemistry by M.N. Chatterjee and Rana Shinde, Jaypee Brothers, Medical Publishers Pvt Ltd. New Delhi. p 668 - 808.

Suggested Readings

- Notes on Clinical Biochemistry by John K. Candlish (1992) Publisher: World Scientific Publishing Company ISBN: 9810210663 ISBN-13: 9789810210663, 978-9810210663
- Clinical Biochemistry: Metabolic And Clinical Aspects by William J. Marshall, Stephen K. Bangert, Elizabeth S.m. Ed. S.m. Ed. Marshall (2008) Publisher: Elsevier Science Health Science Div ISBN: 0443101868 ISBN-13: 9780443101861, 978-0443101861
- Biochemistry **by** John K. Joseph (2006) **Publisher:** Campus Books International **ISBN:** 8180301109 **ISBN-13:** 9788180301100, 978-8180301100
- Basic Medical Biochemistry: A Clinical Approach by Dawn B., PH.D. Marks, Allan D. Marks Colleen M. Smith (1996) Publisher: Lippincott Williams & Wilkins; illustrated edition ISBN-10: 068305595X ISBN-13: 978-0683055955
- Clinical Chemistry, 6/e Ie by William J Marshall, Stephen K Bangert (2008) Publisher: Else ISBN: 0723434603, ISBN-13: 9780723434603, 978-0723434603
- Tietz Fundamentals of Clinical Chemistry, 6/e by Carl A Burtis, Edward R Ashwood (2008) Publisher: Else ISBN: 8131213749, ISBN-13: 9788131213742, 978-8131213742

BC6B011U: Core Course XI: PHARMACEUTICAL CHEMISTRY

Total hours of instruction: 54. **Hours/week: 3.** **Credit: 3**

Objectives: To introduce the student the basics about Pharmacology so that the student develops an idea about action of drugs that are commonly used for therapy

UNIT I: (6 hours)

Introduction to pharmacology, sources of drugs, dosage forms & routes of administration, mechanism of action, concept of receptors, combined effect of drugs, factors modifying drug action, tolerance & dependence, absorption, distribution. Adverse responses and side effects of drugs: allergy, Drug intolerance, Drug addiction, drugs abuses and their biological effects.

Ref: - Essential of Medical Pharmacology **by** Tripathi K.D (2003) **Publisher:** Jaypee Brothers Medical **ISBN:** 8180611876, **ISBN-13:** 9788180611872, 978-8180611872

UNIT II: (10 hours)

Classification of drugs based on sources: mode of administration, site of action, and absorption of drugs, Drugs distribution and elimination, Role of kidney in elimination Drug metabolism: chemical pathways of drug metabolism, Phase I and Phase II reactions, role of cytochrome P450, non-microsomal reactions of drug metabolism, drug metabolizing enzymes.

Ref: - Essential of Medical Pharmacology **by** Tripathi K.D (2003) **Publisher:** Jaypee Brothers Medical **ISBN:** 8180611876, **ISBN-13:** 9788180611872, 978-8180611872

UNIT III: (12 hours)

Chemotherapy: General Principles of Chemotherapy: Chemotherapy of Parasitic infections, Tuberculosis, Leprosy, Malaria, Fungal infections, viral diseases, Introduction to Immunondulators and Chemotherapy of Cancer.

Ref: - Essential of Medical Pharmacology **by** Tripathi K.D (2003) **Publisher:** Jaypee Brothers Medical **ISBN:** 8180611876, **ISBN-13:** 9788180611872, 978-8180611872

UNIT IV: (14hours)

Mode of action, uses, structure- activity relationship of the following classes of
Drug:

- Androgens and Anabolic steroids • Testosterone, Stanazolol.
- Estrogens and Progestational agents • Progesterone, Estradiol.
- Adrenocorticoids • Prednisolone, Dexamethasone, Betamethasone.
- Antibiotics-Penicillins, Semi-synthetic, penicillins, streptomycin, tetracyclines, Cephalosporins,
- Chloramphenicol, Fluroquinolones.

Ref: - Organic Chemistry Vol-1 6th Edition (s) **by** Finar Il (2008) **Publisher:** Dorling Kindersley (India) Pvt Ltd **ISBN:** 8177585428 **ISBN-13:**9788177585421, 978-8177585421

Ref: - Organic Chemistry Vol-2 5th Edition (s) **by** Finar I.l **Publisher:** Dorling Kindersley (India) Pvt Ltd (2008) ISBN: 817758541X, ISBN**-13:** 9788177585414, 978-8177585414

Indian Pharmacopoeia • Latest edition

British Pharmacopoeia - Latest edition

UNIT V: (12 hours)

Databases of drugs: drug bank, Cambridge structural database (CSD). Virtual screening, Molecular docking,Application of bioinformatics in drug designing process.

Ref: - www.drugbank.ca, www.ccdc.cam.ac.uk/products/csd/

Suggested Readings

- Organic Pharmaceutical Chemistry **by** Harkishan Singh, Kapoor Vk (2004) Publisher**:** Vallabh Publications / Prakashan **ISBN:** 8185731209, **ISBN-13:** 9788185731209, 978-8185731209
- Organic Chemistry Vol-1 6th Edition (s) **by** Finar Il (2008) **Publisher:** Dorling Kindersley (India) Pvt Ltd **ISBN:** 8177585428 **ISBN-13:**9788177585421, 978-8177585421
- Organic Chemistry Vol-2 5th Edition (s) **by** Finar I.l **Publisher:** Dorling Kindersley (India) Pvt Ltd (2008) ISBN: 817758541X, ISBN**-13:** 9788177585414, 978-8177585414
- Foyes Medicinal Chemistry, 6/e **by** David A Williams, Thomas L Lemke (2008) **Publisher:** Lww **ISBN:** 818996030X **ISBN-13:** 9788189960308, 978-8189960308
- Principles Of Organic Medicinal Chemistry **by** Rama Rao Nadendla (2004) **Publisher:** New Age International (p) Limited **ISBN:** 8122415717, **ISBN-13:** 9788122415711, 978-8122415711
- Basic & Clinical Pharmacology **by** Bertram G. Katzung (2006) **Publisher:** Mcgraw-hill Medical Publishing **ISBN:** 0071451536 **ISBN-13:** 9780071451536, 978-0071451536
- Essential of Medical Pharmacology **by** Tripathi K.D (2003) **Publisher:** Jaypee Brothers Medical **ISBN:** 8180611876, **ISBN-13:** 9788180611872, 978-8180611872
- Handbook Of Experimental Pharmacology **by** Kulkarni SK (2007) **Publisher:** Vallabh Publications / Prakashan **ISBN:** 8185731128, **ISBN-13:** 9788185731124, 978-8185731124
- Developing Bioinformatics computer skills by Cynthia gibas and Per Jambeck (2002) Publisher:O�Reilly and Associates ISBN: 81-7366-242-8

Suggested websites for Unit V

- www.drugbank.ca
- www.ccdc.cam.ac.uk/products/csd/

BC6B012U: Core Course XII: SOIL BIOCHEMISTRY

Total hours of instruction: 54. **Hours/week: 3.** **Credit: 3**

Objectives: Soil Biochemistry will provide an introduction to the subject of biochemistry from a perspective that will be particularly applicable to agricultural scientists. It will focus on soil chemistry and process by which soil fertility can be improved.

UNIT I: (12h)

Soil Science: Definition of soils-properties of soils-physical property-components **�** structure and texture **�**soil water, soil, temperature. Chemical properties-soil, mineral water-soil colloids-in exchange reactions-soil fertility and its evaluation, soil organic matter and their transformation into soil-carbon and nitrogen cycle, Soil reactions-soil pH-soil acidity and buffer actions **�** its effect on the availability of nitrogen, phosphorus, potassium, calcium, magnesium, zinc, iron, manganese and sulphuric acid, saline and alkaline soils-their formation and reclamation.

Ref: A Student's Book on Soils and Manures by Sir E. J. Russell (2007) Publisher: Inman Press ISBN: 1406772216 ISBN-13: 9781406772210, 978-1406772210

UNIT II: (12h)

Fertilizers: Nitrogen Fertilizers-effect of nitrogen on plant growth and development **�** importance of nitrogenous fertilizers and classification of nitrogenous fertilizers-nitrate-ammonia, urea and cyanide Phosphate fertilizers-effect of phosphours on plant growth and development. Potassium fertilizers-function of potassium on plant growth, Manures-Bulky organic manures-farm yard manure-handling and storage-method of composting green manuring **�** concentrated organic manures and their chemical composition-oil cakes **�** blood **�** meal **�**fish manures.

Ref: Handbook of Fertilizers by A.f. Gustafson (2007) Publisher: Agrobios (India) ISBN: 8177540319, ISBN-13: 9788177540314, 978-8177540314

UNIT III: (10h)
Pesticides: Classification of insecticides, fungicides and herbicides-mode of action • general methods of application and toxicity • safety measures in using pesticides • metabolism of pesticide residues in food produce cytotoxic and carcinogenic effects of pesticides.

Ref: Principles of Pesticide Chemistry by S.k. Handa (2004) Publisher: Agrobios (India) ISBN: 8177542168, ISBN-13: 9788177542165, 978-8177542165

UNIT IV: (10h)
Fungicides and Herbicides: Fungicides-inorganic sulphur compounds-copper compounds-mercuric compounds • organic dithiocarbamates • dithane M-Bordeaux mixture. Herbicides: Inorganic herbicides • arsenical compounds • Boron compounds-cyanamide, cyanides and thiocyanates. Chlorates and sulphamates • Organic herbicides • nitro compounds • chlorinated compounds • triazine compounds • propionic acid derivatives • urea herbicides.

Ref: A Student's Book on Soils and Manures by Sir E. J. Russell (2007) Publisher: Inman Press ISBN: 1406772216 ISBN-13: 9781406772210, 978-1406772210

UNIT V: (10h)
Biological control of pests: Direct use of pesticide producing microbial sprays like Bacillus thuringiensis, genetic engineering of plants to produce pesticide toxins using Ti plasmids as vectors.

Ref: Bio-pesticide & Integrated Pest Management Author: G.k.gosh (1999) Publisher: Aph Publishing Corporation ISBN: 8176481610 ISBN-13: 9788176481618, 978- 176481618

Suggested Readings

- Soil Microbiology, Ecology And Biochemistry byEldor A. Paul (2006) Publisher: Academic Press ISBN: 0125468075 ISBN-13: 9780125468077, 978-0125468077
- Experiments In Soil Biology And Biochemistry by P.k. Chhonkar, S. Bhadraray, A.k. Patra, T.j. Purakayastha (2007) Publisher: Westville Publishing House ISBN: 8185873321 ISBN-13: 9788185873329, 978-8185873329
- Fundamental Soil Science by Mark S. Coyne, James A. Thompson (2005) Publisher: Delmar Thomson Learning ISBN: 0766842665ISBN-13: 9780766842663, 978-0766842663
- Soil Science Simplified by Neal S. Eash, Cary J. Green, Aga Razvi (2008) Publisher: Blackwell Publishers ISBN: 0813818230 ISBN-13: 9780813818238, 978-0813818238
- Handbook of Fertilizers by A.f. Gustafson (2007) Publisher: Agrobios (India) ISBN: 8177540319, ISBN-13: 9788177540314, 978-8177540314
- The Chemistry of Soils and Fertilizers by Harry Snyder (2008) Publisher: Bibliolife ISBN: 0554763133, ISBN-13: 9780554763132, 978-0554763132
- A Student's Book on Soils and Manures by Sir E. J. Russell (2007) Publisher: Inman Press ISBN: 1406772216 ISBN-13: 9781406772210, 978-1406772210
- Manures, Their Composition, Preparation, and Action upon Soils by Campbell Morfit (2008) Publisher: Bibliolife ISBN:0559178840 ISBN-13:9780559178849, 978-0559178849
- Methods of Analysis of Soils Plants Waters Fertilisers and Organic Manures by Tandon Hls (2005) Publisher: Fertiliser Development Consu/organi ISBN: 8185116555
  ISBN-13: 9788185116556, 978-8185116556
- Green Manuring Principles and Practices by A.j. Pieters (2004) Publisher: Agrobios (India) ISBN: 8177541889, ISBN-13: 9788177541885, 978-8177541885
- Chemistry of Pesticides by N.k. Roy (2006) Publisher: Cbs Publishers & Distributors ISBN: 8123908547 ISBN-13: 9788123908540, 978-8123908540

- Bio-pesticide & Integrated Pest Management Author: G.k.gosh (1999) Publisher: Aph Publishing Corporation ISBN: 8176481610 ISBN-13: 9788176481618, 978- 176481618
- Principles of Pesticide Chemistry by S.k. Handa (2004) Publisher: Agrobios (India) ISBN: 8177542168, ISBN-13: 9788177542165, 978-8177542165

BC6B009U: Core Course Practicals IX:

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objective: To introduce the student to simple basic techniques of Molecular biology and tools of bioinformatics

Molecular biology Experiments:

- DNA isolation - from Plant cell, or Animal cell (goat liver), or Human Blood (Fresh / Stored / Frozen)
- Spectrophotometric analysis of isolated DNA sample
- Agarose Gel electrophoresis
- Gel documentation & photography
- DNA molecular size determination

Bioinformatics:

- Internet basics
- Introduction to NCBI Web sites
- Introduction to Data bases

References:

- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 15 – 109
- Bioinformatics for Dummies by Jean-Michel Claverie,PhD and Cedric Notredame,PhD (2007) Publishers: Wiley Publishing, Inc. NJ ISBN13: 978-0-470-08985-9 ISBN10: 0-470-08985-7

BC6B010U: Core Course Practicals X:

Total hours of instruction: 54. Hours/week: 3. Credit: 1

Objectives: Apply biochemical analysis and reasoning in order to solve problems related to physiology and cellular physiopathology.

1. Qualitative tests of urine: Abnormal constituents

   - Proteins (Coagulation test, sulfosalicylic acid test, test for Bence-Jones proteins)
   - Sugars (Benedicts test)
   - Haemoglobin (Benzidine test)
   - Ketone bodies (Rothera test, Gerhardt's test)
   - Bile pigments (Fouchet's test, Gmelin's test)
   - Bile salts (Hay's test)

2. Quantitative estimation in urine:

   - Sugar by Nelson & Somogyi Method
   - Chloride
   - Urea by Diacetylmonoxime Method
   - Uric acid using Phosphotungstic acid reagent
   - Creatinine by Jaffe's reaction
   - Bilirubin by van den Bergh reaction

3. Preparation of Blood Serum & Plasma

4. Quantitative estimation in Blood/ Serum:

   - Glucose by Nelson & Somogyi Method
   - Cholesterol by Zak & Henly's Metod
   - Urea by Diacetylmonoxime Method
   - Iron by ά ά dipyridyl method
   - Total Protein by Biuret Method
   - Albumin: Globulin ratio

   - Uric acid using Phosphotungstic acid reagent
   - Bilirubin by van den Bergh reaction
   - Hemoglobin content by cyanmethaemoglobin method

5. ESR, PCV, TC/DC count,

6. Clinical Enzymology:

   - Assay of serum alkaline phosphatase
   - Assay of Serum alanine amino transferases (ALT/SGPT)
   - Assay of serum aspartate amino transferases (AST/SGOT)
   - Assay of serum Lactate dehydrogenases

References

- Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi ISBN 81-88237-41-8, p 191 -241
- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 15 – 109
- Standard Methods of Biochemical Analysis, S. K. Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, p 49- 181, p 269- 285
- Practical Clinical Chemistry, Harold Varley, CBS Publishers and Distributors, New Delhi, p327 - 348

BC6B011U: Core Course Practicals XI:

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objective: The student is expected to have an in-depth practical analysis of natural products on completion of this course

1. Thin Layer Chromatography of Plant Metabolites:

- TLC of Volatile Oils
- TLC of Alkaloids
- TLC of Glycosides
- TLC of Flavonoid drugs
- TLC of Cardiac Glycosides

2. Extractions, Isolation and Analysis of Phytopharmaceuticals:

- Different Extraction Protocols: Infusion, Decoction, Digestion, Maceration, Soxhlet extraction
- Selection of suitable extraction Process
- Extraction of High Molecular Weight Carbohydrates
- Collection and Purification of Exudates
- Extraction of Total Alkaloids
- Isolation and Colorimetric estimation of Solanine from Potato

- Isolation and Spectrophotometric estimation of Tropane alkaloids from Datura Species
- Isolation and Spectrophotometric estimation of Cinchona Alkaloids from Cinchona bark
- Extraction of Oleoresins from black pepper and ginger
- Isolation and spectrophotometric analysis of Tannins
- Estimation of Total Phenols
- Estimation of Flavanols

References:

- Herbal Drug Technology, S. S. Agarwal & M. Paridhavi (eds), Universities Press, Hyderadad, India, ISBN 13:978-81-7371-579-2 p 231 - 439
- Standard Methods of Biochemical Analysis, S. K. Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, p 49- 181, p 287 - 302

BC6B012U: Core Course Practicals XII:

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objective:- To provide students a practical knowledge about soil analysis.

1. Determination of Chemical and Physical Soil Properties

A. Soil pH
B. Soil Organic Matter – Soil Organic Carbon
Dry Combustion Method
Loss on Ignition Method (LOI)
C. Soil Nutrients: Total Nitrogen
Dry Combustion Method (“Elemental Analysis”)
Modified Kjeldahl Method
D. Soil Nutrients: Inorganic Nitrogen
Extraction
Quantification of Nitrate Nitrogen
Quantification of Ammonium Nitrogen
E. Soil Nutrients: Phosphorus
Extraction of Total Phosphorus
Extraction of Labile Phosphorus
Quantification of Phosphorus

2. Quantification of Soil Microbial Biomass by Fumigation-Extraction

A. Fumigation and Extraction
B. Biomass carbon
Biomass C by Dichromate Oxidation
Biomass C by UV-Persulfate Oxidation
Biomass C by Oven Oxidation
C. Biomass N
Ninhydrin-Reactive Nitrogen
Total Nitrogen

3. Determination of Aerobic N-Mineralization

4. Determination of Enzyme Activities in Soil

Lipase-Esterase Activity
Fluorescein Diacetate Hydrolytic Activity
Dehydrogenase Activity

Reference:

- Manual for Soil Analysis Monitoring and Assessing Soil Bioremediation, Rosa Margesin Franz Schinner (Eds.) Springer Berlin Heidelberg New York ISBN-10 3-540-25346-7 p47-91, 281-294, 303, 309-319

Choice Based Open Course Offered to
Students of Other Departments (5th Semester)

BC5D001U: Open Course I: Human Health and Nutrition

Total hours of instruction: 72. Hours/week: 4. Credit: 4

Objectives: To provide the students with an in-depth study on different aspects of Human health and nutrition

Unit I: (20 h)

Basic concept of food, nutrition and health: Concepts of nutrition, classification, protein, fat, carbohydrate, fiber, and vitamin, mineral and trace elements. Nutritional profile principal foods- Cereals, pulses, vegetables, fruits, nuts, oil seeds, animal foods, milk and milk products, egg, fish, meat, drinks and spices. Nutritional requirements- concepts, energy, Energy requirements protein quality, fat carbohydrate Balanced diet- for different ages, sex, occupation etc Functions of food, Components of food- nutrients, their functions and sources. Food groups and the concept of balanced diet Nutritional status indicators, Nutritional needs during the life cycle (infancy to old age) including physiological conditions like pregnancy and lactation. Socio-Economic Aspects of Nutrition, Health status in India, & Kerala, Nutrigenomics and customized nutrition, Functional foods: food safety and quality.

Unit II: (14 h)

Nutritional Programmes: National programmes related to nutrition, Vitamin A deficiency programme, National iodine deficiency disorders (IDD) programme, Mid-Day meal programme, Integrated child development scheme (ICDS), National and International agencies working towards food/nutrition: NIPCCD, CARE, FAO, NIN, CFTRI (Central food technology & research institute) etc. Assessment of nutritional status.

Unit III: (7 h)

Food additives- colors, preservatives, Food adulteration, Household level food preservation and storage, Food labeling.

Unit IV: (7 h)

Food Processing: (i) Methods of cooking, (ii) Healthy cooking practices, (iii) Food hygiene: Potable water-sources and methods of purification, Food and Water born infections.

Unit V: (24 h)

Major nutritional deficiency diseases- Protein Energy Malnutrition, Vitamin A deficiency, Iron deficiency anemia, Iodine deficiency disorders, their causes, symptoms, treatment, prevention and government programmes, if any. Life style related diseases- hypertension, diabetes mellitus, and obesity- their causes and prevention through dietary/lifestyle modifications. Social health problems- smoking, alcoholism, drug dependence and Aquired Immuno Deficiency Syndrome (AIDS), Diseases related to mineral deficiency, e.g. osteomalacia and anemia. Obesity and

malnutrition including protein-energy malnutrition, Lifestyle diseases including circulation and coronary heart diseases, Diabetes and inherited metabolic diseases, Food allergy. Diseases related to nutrition in the developing countries versus the industrialized world.

Suggested Readings

- Food Additives Characteristics Detection & Estimation **by** Mahindru S N (2000) **Publisher:** Tata Mcgraw Hill Publishing Co Ltd **ISBN:** 0074637355 **ISBN-13:** 9780074637357, 978-0074637357
- Potable Water **by** S.N. Mahindru (2004) **Publisher:** Aph Publishing Corporation **ISBN:**
- 8176487252, ISBN**-13:** 9788176487252, 978-8176487252

- Food: the Chemistry Of Its Components 4th/ed **by** T. P. Coultate (2002) **Publisher:** Royal Society Of Chemistry **ISBN:**0854046151 **ISBN-13:** 9780854046157, 978-0854046157
- Food Hygiene **by** Kavita Ed Marwaha (2007) **Publisher:** Daya Publishing House ISBN**:** 8189729721 **ISBN-13:** 9788189729721, 978-8189729721
- Principles Of Human Nutrition **by** Martin Eastwood (2003) **Publisher:** Atlantic Publishers & Distributors **ISBN:** 1405120290 **ISBN-13:** 9781405120296, 978-1405120296
- Health, Nutrition And Diseases by Chatterjee, G. (2000) **Publisher:** Rajat Publication **ISBN:** 8187317566 **ISBN-13:** 9788187317562, 978-8187317562
- Nutrition And Dietetics **by** Shubhangini A Joshi (2007) **Publisher:** Tata Mgraw Hill **ISBN:**0070472920 **ISBN-13:** 9780070472921, 978-0070472921
- A Handbook Of Foods And Nutrition **by:** F.C. Blank (2007) **Publisher:** Agrobios (India) (ISBN: 8177541633 **ISBN-13:** 9788177541632, 978-8177541632
- Chemical Analysis Of Foods And Food Products, **by** M B Jacobs (1999) **Publisher:** Cbs ISBN**:** 8123906439 **ISBN-13:** 9788123906430, 978-8123906430
- Nutrition Research: Current Scenario And Future Trends **by** Krishnaswamy **Publisher:** Oxford & Ibh Publishing Co. Pvt Ltd **ISBN:** 8120413245 **ISBN-13:** 9788120413245, 978-8120413245

BC5D002U: Open Course II: ENVIRONMENTAL BIOCHEMISTRY.

Total hours of instruction: 72. Hours/week: 4. Credit: 4

Objective:- To provide the students a basic knowledge of the various environmental problems, how it will affect the human population and its social impacts.

Unit I: (14h)

Ecosystems: Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of the following ecosystem:

- Forest ecosystem
- Grassland ecosystem
- Desert ecosystem
- Aquatic ecosystems (ponds, streams, lakes, rivers, ocean estuaries)

Unit II: (14h)

Environmental Pollution: Definition, Causes, effects and control measures of:

- Air pollution
- Water pollution
- Soil pollution
- Marine pollution
- Noise pollution
- Thermal pollution
- Nuclear pollution

Unit III: (16h)

Natural Resources:

- Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people.
- Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.
- Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources,
- Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity,
- Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources,
- Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification.

Role of an individual in conservation of natural resources, equitable use of resources for sustainable lifestyles.

Unit IV: (14h)

Human Population and the Environment: Population growth, variation among nations, Population explosion – Family Welfare Programmes, Environment and human health, human Rights, Value Education, HIV / AIDS, Women and Child Welfare, Role of Information Technology in Environment and Human Health

Unit V: (14h)

Social Issues and the Environment: From unsustainable to sustainable development, Urban problems and related to energy, Water conservation, rain water harvesting, watershed management, Climate change, global warming, acid rain, ozone layer depletion, wasteland reclamation, Consumerism and waste products, Environmental Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act, Issues involved in enforcement of environmental legislation.

Suggested Readings:

- Environmental Chemistry by Soumitro Ghose Publisher: Dominant Publishers & Distributors (2003) ISBN: 8178881381 ISBN-13: 9788178881386, 978-8178881386
- Environmental Chemistry by Colin Baird, Michael Cann (2008) Publisher: W.H. Freeman & Company ISBN: 1429201460 ISBN-13: 9781429201469, 978-1429201469
- Environmental Chemistry In Society by James M. Beard (2008) Publisher: Taylor & Francis ISBN: 1420080253 ISBN-13: 9781420080254, 978-1420080254
- Fundamental Concepts Of Environmental Chemistry by G.S. Sodhi (2005) Publisher: Narosa Publishing House ISBN: 8173196923 ISBN-13: 9788173196928, 978-8173196928
- An Introduction To Environmental Chemistry by J.E. Andrews (2003) Publisher: Blackwell Science Ltd ISBN: 0632059052 ISBN-13: 9780632059058, 978-0632059058
- Introductory Chemistry For Environmental Science by Harrison R.M, De Mora S. J (1998) Publisher: Cambridge University Press ISBN: 0521586887 ISBN-13: 9780521586887, 978-0521586887
- Environmental Chemistry by Sindhu P.S (2002) Publisher: New Age International (p) Ltd ISBN: 812241401X ISBN-13: 9788122414011, 978-8122414011

BC5D003U: Open Course III: Waste Management

Total hours of instruction: 72. Hours/week: 4. Credit: 4

Objective: The primary goal of this course is to provide students with a comprehensive understanding of solid waste management from an environmental/public health perspective.

Unit I: (15 h.)

Basics of Environment and Energy: Basic principle of Environmental science, factors influencing environment: Energy and environment: Sun as source of energy, solar radiation and its characteristics, Fossil fuels: Classification, composition energy content of coal, petroleum and natural gases. Bioenergy: energy from biomass and biogas. Environmental implication of energy use: carbon dioxide emissions, global warming, air pollution

Unit II: (16 h.)

Introduction, Characterization & Monitoring of Solid Waste: What is solid waste; Origin of solid waste: Sources of Solid Waste. Waste generation, trends, quality and quantity of solid waste, Types of solid waste Municipal waste, urban -, rural - and industrial wastes, Special waste: tyres, household hazardous wastes, debris, demolition waste, wet batteries; factory waste; domestic waste; sewage sludge and municipal waste; slaughterhouse waste; agricultural waste; dredged material; Mining waste Hazardous wastes.

Sampling and characterization of wastes Solid waste characterization and monitoring Waste identification; Unknown solid wastes; Environment monitoring; biomonitoring of solid wastes and their disposal facilities; Vadose and saturated zone monitoring of solid waste sites in mining waste dumps; Evaluation of ground water pollution and protection at disposal sites; susceptibility to aquifers.

Unit III: (15h.)

Waste Management: Need, Planning & Techniques: Waste generation, Need and requirements for management and planning, Waste minimization Systems of waste reduction and materials recovery, Waste reduction at source; Collection techniques, Materials and resource recovery/recycling, Transport of solid waste and its optimization; Waste management practices: Quality assurance and quality control checks.

Public education; Solid waste management policies for 21^{st} century; Treatment and disposal techniques - The concept, technique, sound technical option, environmental impacts, and problems of the following techniques: Open dumping, Simple Landfill, Environmentally safe landfill, Simple composting, Vermi-composting, Incineration, non-incineration thermal techniques, Burning, Refuse derived fuels, Deep burying, recycling and re-use, volume reduction, Value addition Individual *vs*. common treatment / disposal practices; Integrated waste management

Unit IV: (10 h.)

Environmental Toxicology and Management of Hazardous Waste: What is Hazardous waste; Environmental problems of Hazardous wastes Health risks associated with hazardous wastes Management of Radioactive waste; Dangers of dumping of hazardous wastes, Generation, collection, segregation, treatment, transport,

and disposal of hazardous waste Evaluation of Toxicity: Evaluation of LC_{50}, LD_{50}, LCIC and IT, Biochemical Effects of Heavy Metals Hg, Pb, As, CN, Cd Lead and Mercury poisoning, Toxic Chemical in the Environment Hazardous waste

Unit V: (16 h.)

Management of Biomedical /Hospital Waste: Public Health, Sanitation and Hygiene: Epidemiological studies – descriptive and analytical, markers and indicators of pollutants in the body, Water borne, air borne, vector- borne, genetic, contagious and non-contagious diseases and their management, Sanitation measures to control infectious diseases

Biomedical waste: Introduction, Hospital Waste: definition Classification of hospital wastes; their types and composition, Types of solids, liquids, sharps, blood and blood tissue, radioactive material, biological and chemical material. Requirement of management Hospital effluents: Nature and composition; Levels of Generation in a small clinic, nursing home, Documentation of Biomedical waste types, Storage of hospital waste; Types of bags and containers used for storage; Segregation of biomedical waste into different type; Handling and transport of hospital waste; Transport of medical waste, Methods / treatments required for disposal of pathogens.

Waste prevention, waste levels, Waste reduction activities; Waste recycling Waste disposal; disposal methods; On-site and off-site management; Techniques of waste management; Protocols for HW management Incineration, autoclaving; microwave radiations, chemical treatments; Guidelines for development of incinerators; Biomedical Waste Treatment Facility: Introduction, location, land requirements, coverage area, types of equipment, infrastructure requirements, record keeping, collection, transport and storage facilities, cost-sharing between production sources and waste treatment operator, Precautions required. Hospital Effluent treatment plant: its structure and Functioning.

Suggested Readings

1. Solid Waste Management in India/R.K. Sinha. Delhi, Indian Pub., 2000, 127 p., ISBN 81-7341-168-9.
2. Handbook of Solid Waste Management Edition Number 2 By George Tchobanoglous, Frank Kreith ISBN 0071356231 / 9780071356237 Publisher McGraw-Hill Country United States
3. Integrated Solid Waste Management: A Life Cycle Inventory (2nd edition) Authors: Forbes McDougall, Peter White, Marina Franke, Peter Hindle, Procter & Gamble (www.pg.com) Publisher: Blackwell Science Ltd., 2001, ISBN 0-632-05889-7
4. Environmental and Health Impact of Solid Waste Management Activities R M Harrison (Editor), Ron E Hester (Editor) ISBN: 978-0-85404-285-2
5. The Solid waste handbook: a practical guide By William D. Robinson Contributor William D. Robinson Edition: illustrated Published by Wiley-IEEE, 1986 ISBN 0471877115, 9780471877110
6. Improving municipal solid waste management in India: a sourcebook for policymakers and practitioners By Da Zhu, P. U. Asnani, World Bank Institute, Chris Zurbrugg, Sebastian Anapolsky, Shyamala Mani Edition: illustrated Published by World Bank Publications, 2007 ISBN 0821373617, 9780821373613
7. Basics of solid and hazardous waste management technology By Kanti L. Shah Edition: 7, illustrated Published by Prentice Hall, 2000 Original from the University of Michigan Digitized 4 Dec 2007 ISBN 0139603786, 9780139603785
8. Waste management practices: municipal, hazardous, and industrial By John Pichtel Edition: illustrated Published by CRC Press, 2005 ISBN 0849335256, 9780849335259

9. Hazardous waste management By Michael D. LaGrega, Phillip L. Buckingham, Jeffrey C. Evans Edition: illustrated Published by McGraw-Hill, 1994 Original from the University of Michigan Digitized 4 Dec 2007 ISBN 0070195528, 9780070195523
10. Integrated Modelling of Solid Waste in India Published by IIED ISBN 1843693046, 9781843693048
11. Environmental science: systems and solutions By Michael L. McKinney, Robert M. Schoch Edition: 3, illustrated Published by Jones & Bartlett Publishers, 2003 ISBN 0763709182, 9780763709181
12. Environmental pollution and control By Ruth F. Weiner, P. Aarne Vesilind Edition: 4, illustrated Published by Elsevier, 1997 ISBN 0750698993, 9780750698993

CORE CHOICE BASED COURSES FOR STUDENTS OF
B.Sc. BIOCHEMISTRY

BC6B013U: Core Choice based I: Health and Nutrition

Total hours of instruction: 72. Hours/week: 4. Credit: 3

Objective: To provide the students with an in-depth study on different aspects of Human health and nutrition

Unit I: (20 h)

Basic concept of food, nutrition and health: Concepts of nutrition, classification, protein, fat, carbohydrate, fiber, and vitamin, mineral and trace elements. Nutritional profile principal foods- Cereals, pulses, vegetables, fruits, nuts, oil seeds, animal foods, milk and milk products, egg, fish, meat, drinks and spices. Nutritional requirements- concepts, energy, Energy requirements protein quality, fat carbohydrate, Balanced diet- For different ages, sex, occupation etc Functions of food, Components of food- nutrients, their functions and sources. Food groups and the concept of a balanced diet, Nutritional status indicators, Nutritional needs during the life cycle (infancy to old age) including physiological conditions like pregnancy and lactation. Socio-Economic Aspects of Nutrition, Health status in India, & Kerala, Nutrigenomics and customized nutrition. Functional foods: food safety and quality.

Unit II: (14 h)

Nutritional Programmes**:** National programmes related to nutrition, Vitamin A deficiency programme, National iodine deficiency disorders (IDD) programme, Mid-Day meal programme, Integrated child development scheme (ICDS), National and International agencies working towards food/nutrition: NIPCCD, CARE, FAO, NIN, CFTRI (Central food technology & research institute) etc. Assessment of nutritional status.

Unit III: (7 h)

Food additives- colors, preservatives, Food adulteration, Household level food preservation and storage, Food labeling.

Unit IV: (7 h)

Food Processing: (i) Methods of cooking, (ii) Healthy cooking practices, (iii) Food hygiene: Potable water-sources and methods of purification, Food and Water born infections.

Unit V: (24 h)

Major nutritional deficiency diseases- Protein Energy Malnutrition, Vitamin A deficiency, Iron deficiency anemia, and Iodine deficiency disorders, their causes, symptoms, treatment, prevention and government programmes, if any.

Life style related diseases- hypertension, diabetes mellitus, and obesity- their causes and prevention through dietary/lifestyle modifications.

Social health problems- smoking, alcoholism, drug dependence and Aquired Immuno Deficiency Syndorme (AIDS), Diseases related to mineral deficiency, e.g. osteomalacia and anaemia.

Obesity and malnutrition including protein-energy malnutrition, Lifestyle diseases including circulation and coronary heart diseases, Diabetes and inherited metabolic diseases, Food allergy, Diseases related to nutrition in the developing countries versus the industrialized world.

Suggested Readings

- Food Additives Characteristics Detection & Estimation by Mahindru S N (2000) Publisher: Tata Mcgraw Hill Publishing Co Ltd ISBN: 0074637355 ISBN-13: 9780074637357, 978-0074637357
- Potable Water by S.N. Mahindru (2004) Publisher: Aph Publishing Corporation ISBN:
- 8176487252, ISBN-13: 9788176487252, 978-8176487252
- Food: the Chemistry Of Its Components 4th/ed by T. P. Coultate (2002) Publisher: Royal Society Of Chemistry ISBN:0854046151 ISBN-13: 9780854046157, 978-0854046157
- Food Hygiene by Kavita Ed Marwaha (2007) Publisher: Daya Publishing House ISBN: 8189729721 ISBN-13: 9788189729721, 978-8189729721
- Principles Of Human Nutrition by Martin Eastwood (2003) Publisher: Atlantic Publishers & Distributors ISBN: 1405120290 ISBN-13: 9781405120296, 978-1405120296
- Health, Nutrition And Diseases by Chatterjee, G. (2000) Publisher: Rajat Publication ISBN: 8187317566 ISBN-13: 9788187317562, 978-8187317562
- Nutrition And Dietetics by Shubhangini A Joshi (2007) Publisher: Tata Mgraw Hill ISBN:0070472920 ISBN-13: 9780070472921, 978-0070472921
- A Handbook Of Foods And Nutrition by: F.C. Blank (2007) Publisher: Agrobios (India) (ISBN: 8177541633 ISBN-13: 9788177541632, 978-8177541632
- Chemical Analysis Of Foods And Food Products, by M B Jacobs (1999) Publisher: Cbs ISBN: 8123906439 ISBN-13: 9788123906430, 978-8123906430
- Nutrition Research: Current Scenario And Future Trends by Krishnaswamy Publisher: Oxford & Ibh Publishing Co. Pvt Ltd ISBN: 8120413245 ISBN-13: 9788120413245, 978-8120413245

BC6B014U: Core Choice based II: Biochemical and Environmental Toxicology

Total hours of instruction: 72. Hours/week: 4. Credit: 3

Objectives: This course intends to introduce the students into basics of toxicology and to make them understand the mechanisms by which biological systems are affected by pollutants

Unit I: (15 h)

Definition and scope of toxicology: Eco-toxicology and its environmental significance, Toxic effects: basis for general classification & nature. Dose- Response relationship: Synergism and Antagonism. Determination of ED_{50} & LD_{50} values Acute and chronic exposure Factors influencing toxicity, Principles and procedures of testing for acute toxic effects: mammalian systems affected & Clinical signs of systemic toxicity. Factors affecting acute toxicity studies

Unit II: (15 h)

Toxicity testing: Test protocol, Genetic toxicity testing & Mutagenesis assay.

In vitro test systems: bacterial mutation tests- Reversion test, Ames test, Fluctuation test, and Eukaryotic mutation test.

In vivo test systems: Mammalian mutation test- Host mediated assay and Dominant Lethal test. Biochemical basis of toxicity: Mechanism of toxicity: Disturbance of excitable membrane function, Altered Calcium hemostasis, Covalent binding to cellular macromolecules & genotoxicity, Tissue specific toxicity.

Unit III: (15h)

Environmental consequences of Pesticide toxicology, Toxicology of: food additives, metals, common drugs like Paracetamol.

Common air pollutants and their sources, Air pollution and its effect on Ozone layer, Industrial effluent toxicology and its effect on environment and health Toxic effects on mammalian tissues.

Unit IV: (15h)

Xenobiotic metabolism: Absorption and distribution, Phase I reaction- Oxidation-reduction, hydrolysis & hydration, Phase II reaction- Conjugation: Methylation, Glutathione and amino acid conjugation. Detoxification.

Unit V: (12 h)

Overview of regulatory agencies, management of toxicological risks, regulatory approaches, Regulatory system and organization

Suggested Readings

- Principles Of Toxicology **by:** Karen E. Stine, Thomas M. Brown 2006 **Publisher:** Crc Press **ISBN:**084932856X **ISBN-13:** 9780849328565, 978-0849328565
- Principles Of Biochemical Toxicology **by** John A. Timbrell **Publisher:** Informa Healthcare **ISBN:**0849373026 **ISBN-13:** 9780849373022, 978-0849373022
- Environmental Toxicology **by** Sigmund F. Zakrzewski, (2002) **Publisher:** Oxford University Press, USA **ISBN:**0195148118 **ISBN-13:** 9780195148114, 978-0195148114

BC6B015U: Core Choice based III: Plant Biochemistry

Total hours of instruction: 72. Hours/week: 4. Credit: 3

Objectives: - This course intends to introduce the students into basics of plant biochemistry. This course will make them aware of the different type of biochemical reactions taking place in plants. Also the students are exposed to the value added products of plants.

Unit I: (12 h)

Photosynthesis: Ultra structure and organization of chloroplast membranes, lipid composition of chloroplast membranes, electron transport chain. Thylakoid membrane protein complexes Calvin cycle: Biochemistry of RuBP carboxylase/oxygenase, activation of RUBISCO, oxygenation reaction, stereochemistry of RUBISCO, Hatch and slack pathway, CAM plants; productivity of C4 plants, photorespiration and compensation point, photosynthetic efficiency and plant productivity. Regulation of enzymes of carbon dioxide fixation by light.

Unit II: (12 h)

Nitrogen Metabolism: Nitrogen fixation, nitrogenase complex, electron transport chain and mechanism of action of nitrogenase. Structure of ﷺNIFﷺ genes and its regulation, Hydrogen uptake and bacterial hydrogenases, Nitrate Metabolism: Enzymes of nitrate metabolism, regulation of their synthesis and activity. Ammonium assimilation enzymes: glutamine synthetase, glutamate synthase and GDH. Water and mineral balance in plants

Unit III: (10 h.)

Plant growth regulators: Auxins, gibberellins, Cytokines, abscicic acid and ethylene-biosynthesis and their metabolic functions, synthetic growth hormones, inhibitors. Biosynthetic origin of secondary metabolites from primary metabolites.

Distinction between primary and secondary metabolites, Occurrence and distribution of secondary metabolites in taxonomically distinct plants, Distribution in various plant parts and at different

developmental stages in plants

Unit IV: (18h.)

Major chemical classes of secondary metabolites: A brief account of the following classes: Alkaloids, terpenoids, flavonoids, phenolics and phenolic acids, steroids, coumarins, quinines, acetylenes, cyanogenic glycosides, amines and non-protein amino acids, gums, mucilages, resins etc. (Structures not necessary. Give examples of the compounds and the plants in which present and their importance).

Importance of secondary metabolites: Protection of the producer plant from predators and insects; importance to man as active principles exerting physiological effects to mammalian systems. Uses of secondary metabolites to man: as drugs, precursors of drugs in pharmaceutical industry, as natural pesticides/insecticides; other uses of secondary metabolites.

Unit V: (20 h)

General biosynthetic pathways and functions of the following classes of secondary metabolites (structures of intermediates not necessary):

- Terpenoids: Isoprene as precurosor, hemi, mono, sesqui, di, triperenes and polyterpenes with examples and important members; their functions.
- Phenols: simple phenols, phenol carboxylic acids, phenylpropanes, flavan derivatives, and phenolic glycosides. Broad outline of their biosynthesis and functions in plants and uses
- Alkaloids: Definition of true and pseudo alkaloids; phenylethylamines, pyrrolidone alkaloids, piperidine alkaloids, pyridine alkaloids, tropane alkaloids, quinoline and isoquinoline alkaloids, indole alkaloids, purine alkaloids, isoprenoid alkaloids, steroidal alkaloids.

Suggested Readings

- Plant Metabolism by H.D. Kumar and H.N. Singh (1980) Publisher: Macmillan (Mar 1980) ISBN-10: 0333256387 ISBN-13: 978-0333256381
- Biotechnology: Secondary Metabolites by K.G. Ramawat, (2000) Publisher: Science Publishers,U.S. ISBN-10: 1578080576 ISBN-13: 978-1578080571
- Plant Biochemistry by P. M. Dey and J. B. Harborne (Editors) (1997) Publisher: Academic Press ISBN-10: 0122146743, ISBN-13: 978-0122146749
- Plant Metabolism by Prof David T. Dennis, Prof David H. Turpin, Dr Daniel D. Lefebvre and Dr David B. Layzell (Editors) (1997) Publisher: Longman; ISBN-10: 0582259061, ISBN-13: 978-582259065
- Plant Biochemistry by Hans-Walter Heldt Professor Em (3ed 2004) Publisher: Academic ISBN-10: 0120883910 ISBN-13: 978-0120883912
- The Principles of Plant Biochemistry by Murield Wheldale Onslow (1931) Publisher: Cambridge University Press ASIN: B002BJMX1M

BC6B016U: Core Choice based IV: Waste Management

Total hours of instruction: 72. Hours/week: 4. Credit: 3

Objective: The primary goal of this course is to provide students with a comprehensive understanding of solid waste management from an environmental/public health perspective.

Unit I: (15 h.)

Basics of Environment and Energy: Basic principle of Environmental science, factors influencing environment: Energy and environment: Sun as source of energy, solar radiation and its characteristics, Fossil fuels: Classification, composition energy content of coal, petroleum and natural gases. Bioenergy: energy from biomass and biogas. Environmental implication of energy use: carbon dioxide emissions, global warming, air pollution

Unit II: (16 h.)

Introduction, Characterization & Monitoring of Solid Waste: What is solid waste; Origin of solid waste: Sources of Solid Waste. Waste generation, trends, quality and quantity of solid waste, Types of solid waste – Municipal waste, urban -, rural - and industrial wastes, Special waste: tyres, household hazardous wastes, debris, demolition waste, wet batteries; factory waste; domestic waste; sewage sludge and municipal waste; slaughterhouse waste; agricultural waste; dredged material; Mining waste Hazardous wastes.

Sampling and characterization of wastes Solid waste characterization and monitoring Waste identification; Unknown solid wastes; Environment monitoring; biomonitoring of solid wastes and their disposal facilities; Vadose and saturated zone monitoring of solid waste sites in mining waste dumps; Evaluation of ground water pollution and protection at disposal sites; susceptibility to aquifers.

Unit III: (15h.)

Waste Management: Need, Planning & Techniques: Waste generation, Need and requirements for management and planning, Waste minimization Systems of waste reduction and materials recovery, Waste reduction at source; Collection techniques, Materials and resource recovery/recycling, Transport of solid waste and its optimization; Waste management practices: Quality assurance and quality control checks; Public education; Solid waste management policies for 21^{st} century.

Treatment and disposal techniques - The concept, technique, sound technical option, environmental impacts, and problems of the following techniques: Open dumping, Simple Landfill, Environmentally safe landfill, Simple composting, Vermi-composting, Incineration, non-incineration thermal techniques, Burning, Refuse derived fuels, Deep burying, recycling and re-use, volume reduction, Value addition Individual *vs*. common treatment / disposal practices; Integrated waste management.

Unit IV: (10 h.)

Environmental Toxicology and Management of Hazardous Waste: What is Hazardous waste; Environmental problems of Hazardous wastes Health risks associated with hazardous wastes Management of Radioactive waste; Dangers of dumping of hazardous wastes, Generation, collection, segregation, treatment, transport, and disposal of hazardous waste Evaluation of Toxicity: Evaluation of LC 50, LD50, LCIC and IT, Biochemical Effects of Heavy Metals Hg, Pb, As, CN, Cd Lead and Mercury poisoning, Toxic Chemical in the Environment Hazardous waste

Unit V: (16 h.)

Management of Biomedical /Hospital Waste: Public Health, Sanitation and Hygiene: Epidemiological studies – descriptive and analytical, markers and indicators of pollutants in the body, Water borne, air borne, vector- borne, genetic, contagious and non-contagious diseases and their management, Sanitation measures to control infectious diseases.

Biomedical waste: Introduction, Hospital Waste: definition Classification of hospital wastes; their types and composition, Types of solids, liquids, sharps, blood and blood tissue, radioactive material, biological and chemical material. Requirement of management Hospital effluents: Nature and composition; Levels of

Generation in a small clinic, nursing home, Documentation of Biomedical waste types, Storage of hospital waste; Types of bags and containers used for storage; Segregation of biomedical waste into different type; Handling and transport of hospital waste; Transport of medical waste, Methods / treatments required for disposal of pathogens. Waste prevention, waste levels, Waste reduction activities; Waste recycling Waste disposal; disposal methods; On-site and off-site management.

Techniques of waste management; Protocols for HW management Incineration, autoclaving; microwave radiations, chemical treatments; Guidelines for development of incinerators; Biomedical Waste Treatment Facility: Introduction, location, land requirements, coverage area, types of equipment, infrastructure requirements, record keeping, collection, transport and storage facilities, cost-sharing between production sources and waste treatment operator, Precautions required. Hospital Effluent treatment plant: its structure and functioning.

Suggested Readings

- Solid Waste Management in India/R.K. Sinha. Delhi, Indian Pub., 2000, 127 p., ISBN 81-7341-168-9.
- Handbook of Solid Waste Management Edition Number 2 By George Tchobanoglous, Frank Kreith ISBN 0071356231 / 9780071356237 Publisher McGraw-Hill Country United States
- Integrated Solid Waste Management: A Life Cycle Inventory (2nd edition) Authors: Forbes McDougall, Peter White, Marina Franke, Peter Hindle, Procter & Gamble (www.pg.com) Publisher: Blackwell Science Ltd., 2001, ISBN 0-632-05889-7
- Environmental and Health Impact of Solid Waste Management Activities R M Harrison (Editor), Ron E Hester (Editor) ISBN**:** 978-0-85404-285-2

- The Solid waste handbook: a practical guide By William D. Robinson Contributor William D. Robinson Edition: illustrated Published by Wiley-IEEE, 1986 ISBN 0471877115, 9780471877110
- Improving municipal solid waste management in India: a sourcebook for policymakers and practitioners By Da Zhu, P. U. Asnani, World Bank Institute, Chris Zurbrugg, Sebastian Anapolsky, Shyamala Mani Edition: illustrated Published by World Bank Publications, 2007 ISBN 0821373617, 9780821373613
- Basics of solid and hazardous waste management technology By Kanti L. Shah Edition: 7, illustrated Published by Prentice Hall, 2000 Original from the University of Michigan Digitized 4 Dec 2007 ISBN 0139603786, 9780139603785
- Waste management practices: municipal, hazardous, and industrial By John Pichtel Edition: illustrated Published by CRC Press, 2005 ISBN 0849335256, 9780849335259
- Hazardous waste management By Michael D. LaGrega, Phillip L. Buckingham, Jeffrey C. Evans Edition: illustrated Published by McGraw-Hill, 1994 Original from the University of Michigan Digitized 4 Dec 2007 ISBN 0070195528, 9780070195523
- Integrated Modelling of Solid Waste in India Published by IIED ISBN 1843693046, 9781843693048
- Environmental science: systems and solutions By Michael L. McKinney, Robert M. Schoch Edition: 3, illustrated Published by Jones & Bartlett Publishers, 2003 ISBN 0763709182, 9780763709181
- Environmental pollution and control By Ruth F. Weiner, P. Aarne Vesilind Edition: 4, illustrated Published by Elsevier, 1997 ISBN 0750698993, 9780750698993

SYLLABUS FOR B.Sc. BIOCHEMSITRY AS COMPLEMENTARY SUBJECT

BC1C101U: Complementary Course 1: Elementary Biochemistry

Total hours of instruction: 36. Hours/week: 2. Credit: 2

Objective: Introduce the student to basic concepts of acid and bases and its importance in biological systems, colloidal systems and it applications, measuring concentrations of solutions, understanding the principle of different types of reactions and basics of thermodynamics as applied to biological system

Unit-I: (10h.)

Dissociation of water, ionic product of water, concepts of pH, pOH, simple numerical problems of pH, determination of pH using indicators, pH meter and theoretical calculations. Dissociation of weak acids and electrolytes, Br�nsted theory of acids and bases, shapes of titration curve of strong and weak acids and bases. Meaning of Ka and pKa values, Buffers: buffer action, buffers in biological system, Henderson - Hasselbach equation with derivation, simple numerical problems involving application of this equation.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 36

Unit II: (10h.)

Meaning of true solution, colloidal solution, and coarse suspension, distinction between lyophilic and lyophobic sols, Fundamental study of Donnan equilibrium- application in biological system, Methods of preparation of colloidal solution, membrane permeability, separation of colloidal solutions, elementary study of charge on colloids, Tyndall effect, Application of colloidal chemistry, emulsion and emulsifying agents.

Ref: - Introduction to Biophysics by Pranab Kumar Banerjee (2008) Publishers: S. Chand & Company ltd ISBN: 81-219-3016-2 p 32

Unit III: (8h.)

Biochemistry of Blood: Constituents of blood, types of cells, components of plasma, types of plasma proteins and function. Mechanism of blood clotting (intrinsic and extrinsic pathway), Clotting factors, anticoagulants, fibrinolysis, Brief account of the function and composition of lymph, interstitial fluid, cerebrospinal fluid, bile, saliva, gastric juice

Ref: - Biochemistry by Debajyoti das. Academic publishers. Kolkata.p 350 � 390

Ref: - Text book of Biochemistry by Edward Staunton West, Wilbert R Todd, Howard S Manson and John T Van Bruggen. Macmillan Publishing Company Inc. New York.
p 550 - 629.

Unit IV: (8h.)

Principles and application of:

- Chromatography: Paper, thin layer, ion exchange, affinity & gel filtration
- Electrophoresis: Paper, PAGE, AGE Immunoelectrophoresis, Blotting techniques Colorimetry and Spectrophotometry,
- Differential Centrifugation,

- Radio immunoassay

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p1027

Suggested Readings

- E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974
- Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson
- Michael M. Cox
- Publisher: W. H. Freeman; Fourth Edition edition (April 23, 2004) ISBN-10: 0716743396 ISBN-13: 978-0716743392
- Principles Of Physical Chemistry (2008) by Puri Br, Sharma Lr, Madan S Pathania VishalPublishingCo, IndiaISBN: 8188646008ISBN**-13:** 9788188646005, 978-8188646005
- Textbook Of Medical Biochemistry (third Edition) (Paperback - 2001) by S. Ramakrishnan **Publisher:** Orient Longman **ISBN:** 8125020713 **ISBN-13:** 9788125020714, 978-8125020714

BC1C101U: Complementary Course Practical I

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objective: Resolve quantitative problems concerning the preparation of solutions and buffers. To have a basic understanding of basic separation techniques

1. Preparation of solutions:
   - Percentage solutions,
   - Molar solutions,
   - Normal solutions
   - Dilution of Stock solutions

2. Preparation of buffers using the Henderson Hasselbach equation

3. Preparation of Colloidal solutions:
   Preparation of Colloidal solution of Prussian blue and Arsenious Sulfide by double decomposition
   Preparation of Colloidal Ferric Hydroxide by Hydrolysis
   Preparation of emulsoid solutions

4. Biochemical separation Techniques

- Chromatographic techniques (**Any one to be performed**)
  Separation of amino acids and simple sugars by Paper chromatography (Descending or ascending)
  Separation of amino acids and lipids by Thin Layer chromatography
  Separation of Plant pigments by Column chromatography

5. Colorimetry and Spectrophotometry techniques

- Verification of Beer Lambert's law
- Verification of molar extinction coefficient of any known compound

Reference:

- Hawk's Physiological Chemistry, Bernard L. Oser (ed) TATA McGRAW Hill Publishing Company LTD, New Delhi p 10- 15.
- Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande, I.K International Pvt. LTD, New Delhi, ISBN 81-88237-41-8, p 13- 17, p 39 – 43.
- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 1- 15, 195-303
- Standard Methods of Biochemical Analysis, S. K. Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, p 12 - 18

BC2C102U: COMPLEMENTARY COURSE II: (ELEMENTARY BIOCHEMISTRY- 2)

Total hours of instruction: 36. Hours/week: 2. Credit: 2

Objective: Describe the structural characteristics of the inorganic components of living matter, the different types of simple organic biomolecules, their biologically important derivatives and the structural units of complex biomolecules. Describe the structural characteristics of the different types of complex biomolecules (glycosides, lipids, nucleotides, nucleic acids and proteins) and indicate the constituent units, the links b etween them, and the conformation and grouping of subunits.

Unit I: (10h.)

Isomerism of carbohydrates, relationship- D and L forms of glyceraldehyde – examples of epimers, mutarotation and its explanation by ring structures, anomers, Structure (linear and cyclic structures of glucose, galactose, mannose and fructose). Reducing actions of sugars, Structure of methyl β- D glucopyranose, 2- deoxy β- D ribofuranose. Structure of the following disaccharides (Haworth perspective formulas- maltose, isomaltose, sucrose, lactose trehalose and cellobiose (elucidation of the structures of mono-, di-, and polysaccharides is not included). Structure and important properties of the following Homopolysaccharides – amylose, amylopectin, glycogen, cellulose and chitin, Heteropolysaccharides, classification and functions.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 73

Unit II: (6h.)

Basic ideas about physiological functions of lipids, Fatty acids – classification, structure of the following fatty acids – stearic acid, oleic acid, linoleic acid, Structure of triacylglycerol. Saponification, Definition of saponification number, acid number and iodine number of fats, Structure of: phosphatidic acid, lecithin, cephalin, and phosphatidyl serine, Functions of Sphingolipids. Chemical structure and functions of cholesterol and ergosterol.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 230

Unit III: (12h.)

Name (with one letter code) and structures of the 20 standard aminoacids occurring in proteins, general chemical reactions of aminoacids, Representation of amino acid in the zwitter ionic form, Identification and estimation of aminoacids, Classification and function of Proteins, Elementary study of primary, secondary, tertiary and quaternary structure of proteins. Colour reactions of proteins. Sequencing of proteins (only basic principles of the methods employed), Denaturation of proteins, precipitation reactions and colour reactions of proteins.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 132

Unit IV: (8h.)

Nature of nucleic acids, Structure of purines and pyrimidines, nucleosides, nucleotides, Stability and formation of phosphodiester linkages, Effect of acids, alkali and nucleases on DNA and RNA, Structure of Nucleic acids- Watson-Crick DNA double helix structure, Brief study of: circular DNA, super coiling, helix to random coil transition, Denaturation of nucleic acids- hyperchromic effect, *T*m-values and their significance, Types of RNA and DNA.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 280

Suggested Readings

- Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson
- Michael M. Cox
- Publisher: W. H. Freeman; Fourth Edition edition (April 23, 2004) ISBN-10: 0716743396 ISBN-13: 978-0716743392
- E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974
- Biochemistry [with Cdrom] (2004) by Donald Voet, Judith G. Voet Publisher: John Wiley & Sons Inc ISBN: 047119350X ISBN-13: 9780471193500, 978-0471193500
- Principles Of Biochemistry (1995) by Geoffrey L Zubay, William W Parson, Dennis E Vance Publisher: Mcgraw-hill Book Company – Koga ISBN:0697142752
  ISBN-13: 9780697142757, 978-0697142757
- Principles Of Biochemistry, 4/e (2006) by Robert Horton H , Laurence A Moran, Gray Scrimgeour K Publisher: Pearsarson ISBN: 0131977369, ISBN-13:9780131977365, 978-0131977365
- Biochemistry 6th Edition (2007) by Jeremy M.berg John L.tymoczko Lubert Stryer Publisher: B.i.publicationsPvt.Ltd ISBN:071676766X ISBN-13: 9780716767664, 978-716767664
- Biochemistry (2008) by Rastogi Publisher: Mcgraw Hill ISBN:0070527954 ISBN-13: 9780070527959, 978-0070527959

BC2C102U: Complementary Course Practical II:

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objective: This course aims to provide the students with an opportunity to develop their qualitative analytical skills. It is expected that the student on completion of this course have a sound knowledge on basic protocols for identification of biomolecules.

1. Reactions of Carbohydrates, Amino acids, Proteins and Lipids

A. Carbohydrates: (Glucose, fructose, Galactose, Xylose, Maltose, Lactose, Sucrose, Starch, dextrin, Glycogen maybe given for analysis).
Molisch test, Iodine test, Test for reducing sugars (Fehling's test, Benedict's test, Barfoed's test), Seliwanoff's test, Bial's test, Mucic acid test, Acid hydrolysis of Sucrose, Osazone test
B. Amino acids: (tyrosine, tryptophan,cysteine, cystine, methionine, arginine, proline, histidine may be given for analysis)
Ninhydrin test, Xanthoproteic test, Istatin test, Pauly's diazo test, sakaguchi test, Ehrlich's test, Sodium nitroprusside test, Millon's test, Sullivan's test
C. Proteins: (Casein, Albumin, Gelatin, peptone may be given for analysis).
Biuret test, Ammonium sulfate precipitation test, Sulphosalicylic acid test, Heat coagulation test, test for inorganic phosphate
D. Lipids: Fats (tristearin), Fatty acids (palmitic acid, stearic acid, oleic acid), Glycerol, Steroids, and cholesterol
Solubility in Organic solvents, saponification test, Acrolein test, Test for unsaturation: with bromine water or dilute potassium permanganate or Hubl's iodine test, salkowski test, Zak's test
E. Non Protein nitrogenous compounds: (Urea, Uric acid, Creatinine)
Urease test, Phosphotungstic acid test and Jaffe's test

2. Identification of Monosaccharide, Disaccharide, polysaccharide following a systematic scheme of analysis (Single component from among the above mentioned carbohydrates to be given).
3. Identification of amino acids and proteins following a systematic scheme for analysis (single components only need be given)
4. Identification of lipids following a systematic scheme for analysis (single components only need be given)
5. Identification of NPN following a systematic scheme for analysis (single components only need be given)

Reference:

- Hawk's Physiological Chemistry, Bernard L. Oser (ed) TATA McGRAW Hill Publishing Company LTD, New Delhi, p 60 – 127, 1317- 1334
- Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi ISBN 81-88237-41-8, p 13- 17, p 49 - 72
- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9 p 15- 23, 33- 35, 50 -57.
- Practical Biochemistry, R.C. Gupta & S. Bhargava (eds) CBS Publishers and Distributors, New Delhi, ISBN 81-239-0124-0 p 9 - 27

BC3C103U: Complementary Course iii: (Enzymology and Metabolism -1)

Total hours of instruction: 54 Hours/week: 3. Credit: 2

Objective: Introduces the student to basics of Enzyme catalysis, Explain the general principals of cellular energy metabolism. Explain and schematize the oxidative pathways of Carbohydrates. Explain and schematize the final mitochondrial oxidative pathways: oxidative tricarboxylic cycle and mitochondrial respiratory chain, as well as its coupling to ATP synthesis.

Unit I: (20h.)

History of Enzymology, Classification of enzymes; six major classes of enzymes with one example each, Elementary study of the following factors affecting velocity of enzyme-catalysed reactions – effect of substrate concentration, enzyme concentration, temperature and pH; Michaelis Menten equation (without derivation), Km and its significance The Lineweaver- Burk plot.

Definition of enzyme specificity – an example each for group specificity, optical specificity, geometrical specificity and cofactor specificity of enzymes from the pathways to be studied, Explanation of competitive and non competitive type of inhibition, their destination on the basis of double reciprocal plot, brief study of allosteric inhibition with an example.

Brief study of the activation of zymogen form of enzymes, Activation of SH enzymes and activation of enzymes by prosthetic groups, coenzymes and metal activators, Brief study of allosteric activation with example.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 333

Unit II: (15h.)

Digestion of carbohydrates and absorption of sugars, Reactions of glycolytic sequences with the names of enzymes and intermediates (with structures), Fate of pyruvate in alcoholic fermentation, Substrate level phosphorylation. Glycogenesis and glycogenolysis, Role of cyclic AMP and hormones in glycogen metabolism, Gluconeogenesis and pentose phosphate pathway (with structures of intermediates).

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 458,

Unit III: (12h.)

Decarboxylation of pyruvate, Reactions of citric acid cycle (with structures of intermediates), Calculation of energy yield (as ATP) of aerobic and anaerobic oxidation of carbohydrates, the mitochondria – arrangement of electron carriers in the electron transport chain: Oxidative phosphorylation, site of ATP formation in the electron transport chain, Chemiosmotic hypothesis. Classification of high-energy compounds with an example each.

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 481

Unit IV: (7h.)

Light reactions: cyclic and non-cyclic electron transport and photophosphorylation Dark reactions: the path of carbon- C3 & C4 Pathways (structure not needed), glyoxylate cycle and its significance.

Ref: - Plant Biochemistry by Hans-Walter Heldt Professor Em (3ed 2004) Publisher: Academic ISBN-10: 0120883910 ISBN-13: 978-0120883912

Suggested Readings

- Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson
- Michael M. Cox
- Publisher: W. H. Freeman; Fourth Edition edition (April 23, 2004) ISBN-10: 0716743396 ISBN-13: 978-0716743392
- E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974
- Biochemistry [with Cdrom] (2004) by Donald Voet, Judith G. Voet Publisher: John Wiley & Sons Inc ISBN: 047119350X ISBN-13: 9780471193500, 978-0471193500

- Principles Of Biochemistry (1995) by Geoffrey L Zubay, William W Parson, Dennis E Vance Publisher: Mcgraw-hill Book Company – Koga ISBN:0697142752
  ISBN-13: 9780697142757, 978-0697142757
- Principles Of Biochemistry, 4/e (2006) by Robert Horton H , Laurence A Moran, Gray Scrimgeour K Publisher: Pearsarson ISBN: 0131977369, ISBN-13:9780131977365, 978-0131977365
- Biochemistry 6th Edition (2007) by Jeremy M.berg John L.tymoczko Lubert Stryer Publisher: B.i.publicationsPvt.Ltd ISBN:071676766X ISBN-13: 9780716767664, 978-716767664
- Biochemistry (2008) by Rastogi Publisher: Mcgraw Hill ISBN:0070527954 ISBN-13: 9780070527959, 978-0070527959
- Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins by Nicholas C. Price, Lewis Stevens, and Lewis Stevens (2000) Publisher: Oxford University Press, USA ISBN: 019850229X ISBN-13: 9780198502296, 978-0198502296
- Enzyme Mechanism by P.K. Shivraj Kumar (2007) Publisher: RBSA Publishers
  ISBN: 8176114235 ISBN-13: 9788176114233, 978-8176114233
- Enzymes: Biochemistry, Biotechnology, Clinical Chemistry (second Edition)
  by Trevor Palmer, Philip Bonner (2007) Publisher: Horwood Publishing Limited ISBN: 1904275273 ISBN-13: 9781904275275, 978-1904275275
- Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7
- Plant Biochemistry by Hans-Walter Heldt Professor Em (3ed 2004) Publisher: Academic ISBN-10: 0120883910 ISBN-13: 978-0120883912

BC3C103U: Complementary Course Practical III

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objective: The objective here is to make the students understand the basic steps involved in extraction and determination of enzymatic activities & Calculation enzymatic activities from experimental data

1. Extraction of enzymes: (Minimum of 3 experiments to be done)

- Acid phosphatase from Fresh Potato (*Solanum tuberosum*)
- β- amylase from Sweet potato (*Ipomoea batates*)
- Catalase from Bovine /Porcine liver
- Urease from Jack bean (*Canavalia ensiformis*)
- Phytase from Seeds

2. Enzyme Assay: (Minimum of 2 experiments to be done, enzymes extracted from above experiment can be used)

- Acid phosphatase
- β- amylase
- Catalase
- Urease from Jack bean
- Phytase

References

- Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi ISBN 81-88237-41-8, p 173- 187

- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 110 – 155

- Standard Methods of Biochemical Analysis, S. K. Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, p 184 - 255

BC4C104U: COMPLEMENTARY COURSE IV: (METABOLISM- 2)

Total hours of instruction: 54. Hours/week: 3. Credit: 2

Objective: Explain the general principals of cellular energy metabolism. Explain and schematize the oxidative pathways of Lipids & Proteins. Explain and schematize the final mitochondrial oxidative pathways: oxidative tricarboxylic cycle and mitochondrial respiratory chain, as well as its coupling to ATP synthesis.

Unit I: (10h.)

Outline study of lipid digestion and absorption. Outline study of β-oxidation scheme (with structures). ATP yield in β-oxidation, Cytoplasmic biosynthesis of fatty acid, elongation and desaturase, Physiological functions of phospholipids, Outline study of cholesterol synthesis (without structure).

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 564

Unit II: (10h.)

Proteolytic enzymes of the gastrointestinal tract and their activation (from zymogen forms), Digestion of proteins, Absorption of aminoacids from the intestine, Decarboxylation, deamination and transamination of aminoacids (without molecular mechanisms), Urea cycle, Fate of carbon skeleton: entry into glucogenic and ketogenic pathways. N_2 fixation (detailed study expected).

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 641

Unit III: (16hrs)

Central dogma, the chemical nature of gene- replication of DNA, coding for aminoacids by triplets of bases and transcription of DNA Post transcriptional modification of RNA, Types of RNA, their structural features, their role in protein biosynthesis, Genetic code, translation of mRNA – the ribosomal events, Post-translational modifications of proteins.

Ref: - Cell biology, Genetics, Molecular Biology, Evolution and Ecology by P.S. Verma and V. K. Agarwal (2008) Publisher: S. Chand & Company Ltd ISBN: 81-219-2442-1 p 9, 16, 27, 44, 66, 75, 201

Unit IV: (18h.)

Classification, source, chemical nature and deficiency disorders of vitamins, Basic physiological functions of vitamin C, B_1, B_2, pyridoxine and niacinamide (chemical structures not expected), Biochemical reactions involving TPP, FMN, FAD, NAD^+, $NADP^+$, PLP, CoA and biotin from metabolic sequences prescribed. Fat soluble vitamins A, D, E, K Physiological functions daily requirements, etc.

Minerals: Micro and macro minerals. Calcium, Magnesium, Sodium, Potassium, Iron, Copper, Selenium – biological role and nutritional importance
Classification, mechanism of action (preliminary study), site of biosynthesis, important physiological functions of thyroxine, insulin, glucagon, epinephrine with reference to metabolic pathways (carbohydrate, Lipids and Protein).

Ref: - Fundamentals of Biochemistry by J. L. Jain, Sunjay Jain and Nitin Jain (2008) Publishers: S. Chand & Co Ltd ISBN: 81-219-2453-7 p 959, 988

Suggested Readings

- Lehninger Principles of Biochemistry, Fourth Edition by David L. Nelson
- Michael M. Cox
- Publisher: W. H. Freeman; Fourth Edition edition (April 23, 2004) ISBN-10: 0716743396 ISBN-13: 978-0716743392
- E.S. West, W.R. Todd, H.S. Mason and J.T. van Bruggen, A Text Book of Biochemistry, Oxford and IBH Publishing Co., New Delhi, 1974
- Biochemistry [with Cdrom] (2004) by Donald Voet, Judith G. Voet Publisher: John Wiley & Sons Inc ISBN: 047119350X ISBN-13: 9780471193500, 978-0471193500
- Principles Of Biochemistry (1995) by Geoffrey L Zubay, William W Parson, Dennis E Vance Publisher: Mcgraw-hill Book Company – Koga ISBN:0697142752
  ISBN-13: 9780697142757, 978-0697142757
- Principles Of Biochemistry, 4/e (2006) by Robert Horton H , Laurence A Moran, Gray Scrimgeour K Publisher: Pearsarson ISBN: 0131977369, ISBN-13:9780131977365, 978-0131977365
- Biochemistry 6th Edition (2007) by Jeremy M.berg John L.tymoczko Lubert Stryer Publisher: B.i.publicationsPvt.Ltd ISBN:071676766X ISBN-13: 9780716767664, 978-716767664
- Biochemistry (2008) by Rastogi Publisher: Mcgraw Hill ISBN:0070527954 ISBN-13: 9780070527959, 978-0070527959

BC4C104U: Complementary Course Practical IV

Total hours of instruction: 36. Hours/week: 2. Credit: 1

Objective: To introduce the students to protocols of spectrophotometric determination. Calculate quantities and concentrations of biomolecules from standard curves

A. Estimation of Carbohydrates: (Colorimetric) (Any 3 to be done)
1. Determination of total sugars by ferricyanide method (Colorimetric)
2. Quantitation of total sugars by anthrone method
3. Determination of reducing sugars by Nelson & Somogyi's method
4. Estimation of reducing sugars by dinitrosalicylate method
5. Determination of fructose by Roe's resorcinol method

B. Separation and Estimation of Lipids: (Colorimetric) (Any 2 to be done)
1. Estimation of Cholesterol by Zak's method
2. Determination of acid value of fats
3. Determination of saponification value of fats
4. Determination of iodine number of oils
5. Determination of peroxide value of oils

C. Estimation of Proteins and Amino acids: (Colorimetric) (Any 3 to be done)
1. Estimation of protein by Lowry's method
2. Determination of protein by Biuret method
3. Determination of tyrosine by nitrosonapthol method
4. Estimation of tryptophan by Spies and Chamber's method

D. Estimation of Nucleic acids: (Colorimetric) (Any 1 to be done)
1. Estimation of DNA by Diphenylamine method
2. Determination of RNA by orcinol method

E. Estimation of Minerals and Vitamins (Colorimetric) (Any 1 to be done)
1. Colorimetric estimation of iron in foodstuffs by ά ά dipyridyl method
2. Quantitative determination of thiamine in cereals and food
3. Estimation of ascorbic acid in Lemon juice

References

- Experimental Biochemistry: A Student Companion, Beedu Sasidhar Rao & Vijay Deshpande (ed), I.K International Pvt. LTD, New Delhi ISBN 81-88237-41-8, p 81- 126
- Introductory Practical biochemistry, S. K. Sawhney & Randhir Singh (eds) Narosa Publishing House, New Delhi, ISBN 81-7319-302-9, p 15 - 109
- Standard Methods of Biochemical Analysis, S. K. Thimmaiah (ed), Kalyani Publishers, Ludhiana ISBN 81-7663-067-5, p 49- 181, p 269- 285

ADDITIONAL REFERENCE FOR B.Sc COURSE IN BIOCHEMISTRY UNDER CREDIT-SEMESTER SYSTEM

1. Instant Biochemistry & S.Nagini Ane Books Pvt Ltd., New Delhi, Chennai, Mumbai etc 4821, Parwana Bhavan, 24, Ansari Road, Daryaganj, New Delhi-110002, India.

2. Research methods for the biosciences Debbie Holmes, Peter Moody, Diana Dine & International Student edition Oxford University Press, YMCA Library Building, Jai Singh Road, New Delhi &110001.

3. Experimental Design for the Life Sciences - Second Edition Graema D.Ruxton, Nick Colegrave International Student Edition Oxford University Press, YMCA Library Building, Jai Singh Road, New Delhi-110001.

4. Founation Course in Biology – S.K.Aggarwal Ane Books India, 4821, Parwana Bhavan, 1st Floor, 24 Ansari Road, Darya Ganj, New Delhi-110002, India.

5. Chemistry of Biomolecules by Dr.S.P.Bhutani, Ane, Books Pvt Ltd., 4821, Parwana Bhavan, 1st Floor, 24 Ansari Road, New Delhi, India-110002.

6. Essentials of Modern Biology – Dr.R.C.Sobti of Dr.(Mrs.) V.L.Sharma, Ane Books Pvt Ltd, Parwana Bhavan, 1st Floor, 24, Ansari Road, New Delhi, India-110002.

7. Plant Carbohydrate Chemistry J.A.Bryant, M.M.Burrell and N.J.Kruger, Bios Scientific Publishers Ltd, 9 Newtec Place, Magdalen Road, Oxfor Ox4IRE, UK.

8. Plant Physiology by V.Verma. Ane Books India. Kohinoor Flats, Luke Lane, Ambuja Vilasam Road, Thiruvananthapuram-695001, Kerala.

9. Fundamentals of Biostatistics by Veer Bala Rastogi- Anes Books Pvt.Ltd.

10. Text Book of Economic Botany by V.Verma, Ane Books Pvt.Ltd.

11. Unraveling DNA Molecular Biology for the Laboratory – Michael R.Wintrey, Marc.A.Rott, Alan Wortman published by Dorling Kindersley India Pvt Ltd.

12. Human Molecular Genetics by Peter Sudbery, Edited by Dr.Ed.Wood, Dept.of Biochemistry and Molecular Biology, University of Leeds, U.K

13. Introduction to Bioinformatics Teresa K.Attwod, David.J.Parry-Smith and Samiron Phukan. Edited by Dorling Kindersley (India) Pvt.Ltd., New Delhi, India-110092.