



Draft Syllabus Biochemistry (Hons)

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1. Introduction

The syllabus for Biochemistry at undergraduate level using the Choice Based Credit system has been framed in compliance with model syllabus given by UGC.

The main objective of framing this new syllabus is to give the students a holistic understanding of the subject giving substantial weightage to both the core content and techniques used in Biochemistry.

The ultimate goal of the syllabus is that the students at the end are able to secure a job. Keeping in mind and in tune with the changing nature of the subject, adequate emphasis has been given on new techniques of mapping and understanding of the subject.

The syllabus has also been framed in such a way that the basic skills of subject are taught to the students, and everyone might not need to go for higher studies and the scope of securing a job after graduation will increase.

It is essential that Biochemistry students select their general electives courses from Chemistry, Physics, Mathematics and/or any branch of Life Sciences disciplines.

Also, it is strongly recommended that two Chemistry courses (General and Physical Chemistry and Organic Chemistry) should be made compulsory in the General Electives category. The remaining two courses may be selected from two different disciplines. Thus, Biochemistry (Honours) students get to learn GE courses from three different disciplines.

While the syllabus is in compliance with UGC model curriculum, it is necessary that Biochemistry students should learn "Basic Microbiology" as one of the core courses rather than as elective while. Course on "Concept of Genetics" has been moved to electives.

Also, it is recommended that two elective courses namely Nutritional Biochemistry and Advanced Biochemistry may be made compulsory.

2. Scheme for CBCS Curriculum

2.1 Credit Distribution across Courses

		Credits	
Course Type	Total Papers	Theory + Practical	Theory*
Core Courses	14	$14 \times 4 = 56$ $14 \times 2 = 28$	$14 \times 5 = 70$ $14 \times 1 = 14$
Discipline Specific Electives	4	$4 \times 4 = 16$ $4 \times 2 = 8$	$4 \times 5 = 20$ $4 \times 1 = 4$
Generic Electives	4	$4 \times 4 = 16$ $4 \times 2 = 8$	$4 \times 5 = 20$ $4 \times 1 = 4$
Ability Enhancement Language Courses	2	$2 \times 2 = 4$	$2 \times 2 = 4$
Skill Enhancement Courses	2	$2 \times 2 = 4$	$2 \times 2 = 4$
Totals	26	140	140

*Tutorials of 1 Credit will be conducted in case there is no practical component

Note:

- Biochemistry students will be encouraged to take at least one Chemistry course as General Elective
- Two DSE courses namely Nutritional Biochemistry and Plant Biochemistry may be made compulsory.

2.2 Scheme for CBCS Curriculum

Semester	Course Name	Course Detail	Credits
I	Ability Enhancement Compulsory Course - I	English communication / Environmental Science	2
	Core course - I	Molecules of Life	4
	Core course - I Practical	Molecules of Life	2
	Core course - II	Cell Biology	4
	Core course - II Practical	Cell Biology	2
	Genetic Elective - 1	TBD	4
	Generic Elective - 1 Practical	TBD	2
II	Ability Enhancement Compulsory Course - II	English communication / Environmental Science	2
	Core course - III	Proteins	4
	Core course - III Practical	Proteins	2
	Core course - IV	Enzymes	4
	Core course - IV Practical	Enzymes	2
	Generic Elective - 2	TBD	4
	Generic Elective - 2 Practical	TBD	2
III	Core course - V	Metabolism of Carbohydrates and Lipids	4
	Core course - V Practical	Metabolism of Carbohydrates and Lipids	2
	Core course - VI	Physiology and Hormones	4
	Core course - VI Practical	Physiology and Hormones	2
	Core course - VII	Physical Biochemistry	4
	Core course - VII Practical	Physical Biochemistry	2
	Skill Enhancement Course - 1	TBD	2

	Generic Elective - 3	TBD	4
	Generic Elective - 3 Practical	TBD	2
IV	Core course - VIII	Membrane Biology and Bioenergetics	4
	Core course - VIII Practical	Membrane Biology and Bioenergetics	2
	Core course - IX	Metabolism of Amino Acid and Nucleic Acid	4
	Core course - IX Practical	Metabolism of Amino Acid and Nucleic Acid	2
	Core course - X	Basic Microbiology and Microbial Genetics	4
	Core course - X Practical	Basic Microbiology and Microbial Genetics	2
	Skill Enhancement Course-2	TBD	2
	Generic Elective - 4	TBD	4
	Generic Elective - 4 Practical	TBD	2
V	Core course - XI	Chromosome organization, DNA replication, Mutation and Repair	4
	Core course - XI Practical	Chromosome organization, DNA replication, Mutation and Repair	2
	Core course - XII	Gene expression and regulation	4
	Core course - XII Practical	Gene expression and regulation	2
	Discipline Specific Elective - 1	Nutritional Biochemistry	4
	Discipline Specific Elective - 1 Practical	Nutritional Biochemistry	2
	Discipline Specific Elective - 2	TBD	4
	Discipline Specific Elective - 2 Practical	TBD	2
VI	Core course - XIII	Recombinant DNA Technology and Genetic Engineering	4
	Core course - XIII Practical	Recombinant DNA Technology and Genetic Engineering	2
	Core course - XIV	Immunology	4
	Core course - XIV Practical	Immunology	2

	Discipline Specific Elective - 3	Advanced Biochemistry	4
	Discipline Specific Elective - 3 Practical	Advanced Biochemistry	2
	Discipline Specific Elective - 4	TBD	4
	Discipline Specific Elective - 4 Practical	TBD	2

2.3 Choices for Discipline Specific Electives

Discipline Specific Elective - 2	Discipline Specific Elective - 4
Nervous System and Neuro biochemistry	Molecular Diagnostics
Molecular basis of infectious and non-infectious human diseases	Concept of Genetics
Research Project	

2.4 Choices for Skill Enhancement Courses

Skill Enhancement Course-1 & Skill Enhancement Course-2	
Clinical Biochemistry	Techniques in Biochemistry
Biostatistics and Bioinformatics	Protein Purification and Enzyme assay

3. Core Subjects Syllabus

3.1 Core T1 - Molecules of Life

Molecules of Life	
	4 Credits
The foundations of biochemistry	
Cellular and chemical foundations of life	
Water	
Unique properties, weak interactions in aqueous systems, ionization of water, buffers, water as a reactant and fitness of the aqueous environment.	
Carbohydrates and glycobiology	
Monosaccharides - structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives, oxidation of sugars. Formation of disaccharides, reducing and non-reducing disaccharides. Polysaccharides - homo- and heteropolysaccharides, structural and storage polysaccharides. Structure and role of proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides). Carbohydrates as informational molecules, working with carbohydrates	
Lipids	
Building blocks of lipids - fatty acids, glycerol, ceramide. Storage lipids - triacyl glycerol and waxes. Structural lipids in membranes - glycerophospholipids, galactolipids and sulpholipids, sphingolipids and sterols, structure, distribution and role of membrane lipids. Lipids as signals, cofactors and pigments	
Amino acids	
Structure and classification, physical, chemical and optical properties of amino acids	
Nucleic acids	

Nucleotides - structure and properties. Nucleic acid structure - Watson-Crick model of DNA. Structure of major species of RNA - mRNA, tRNA and rRNA. Nucleic acid chemistry

- UV absorption, effect of acid and alkali on DNA. Other functions of nucleotides - source of energy, component of coenzymes, second messengers

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13: 978-1-4641-0962-1 / ISBN: 10:1-4292-3414-8.
- ▶ Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4.
- ▶ Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4
- ▶ Fundamental of Biochemistry, Voet and Voet, Edited by Prof. Hiren K Das (JNU)

3.2 Core P1 - Molecules of Life Lab

Molecules of Life	
	2 Credits
List of Practical	
1. Safety measures in laboratories, use and calibration of pipettes. 2. Preparation of normal, molar solutions and percent solutions. 3. Concept of pH and preparation of buffers. 4. Determination of Pka of acetic acid and glycine. 5. Separation of amino acids/ sugars/ bases by thin layer chromatography.	

3.3 Core T2 - Cell Biology

Cell Biology	
	4 Credits
Introduction to cell biology	
Prokaryotic (archaea and eubacteria) and eukaryotic cell (animal and plant cells),	
Tools of cell biology	
Cells as experimental models, Light microscopy, phase contrast microscopy, fluorescence microscopy, confocal microscopy, electron microscopy, FACS, Centrifugation for subcellular fractionation.	
Structure of different cell organelles	
Structure of nuclear envelope, nuclear pore complex. ER structure. Organization of Golgi. Lysosome. Structure and functions of mitochondria, chloroplasts and peroxisomes. Zellweger syndrome.	
Cytoskeletal proteins	
Structure and organization of actin filaments. Treadmilling and role of ATP in microfilament polymerization, organization of actin filaments. Non-muscle myosin. Intermediate filament proteins, assembly and intracellular organization. Assembly, organization and movement of cilia and flagella.	
Cell wall and extracellular matrix	
Prokaryotic and eukaryotic cell wall, cell matrix proteins. Cell-matrix interactions and cell- cell interactions. Adherence junctions, tight junctions, gap junctions, desmosomes, hemidesmosomes, focal adhesions and plasmodesmata.	
Protein trafficking	
Selective transport of proteins to and from the nucleus. Regulation of nuclear protein import and export. Targeting proteins to ER, smooth ER and lipid synthesis. Export of proteins and lipids from ER and into ER. Lipid and polysaccharide metabolism in Golgi. Protein sorting and export from	

Golgi. Mechanism of vesicular transport, cargo selection, coat proteins and vesicle budding, vesicle fusion. Protein import and mitochondrial assembly, protein export from mitochondrial matrix. Import and sorting of chloroplast proteins.

Cell cycle, cell death and cell renewal

Eukaryotic cell cycle, restriction point, and checkpoints. Cell division. Apoptosis and necrosis - brief outline. Salient features of a transformed cell.

Reference Books

- ▶ The Cell: A Molecular Approach (2009) 5th ed., Cooper, G.M. and Hausman, R.E., ASM Press & Sunderland (Washington DC), Sinauer Associates, MA, ISBN: 978-0-87893-300-6.
- ▶ Molecular Cell Biology (2012) 7th ed., Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell, J., W.H. Freeman & Company (New York), and ISBN: 13:978-1-4641-0981-2 / ISBN: 10: 1-4641-0981-8.
- ▶ Molecular Biology of the Cell (2008) 5th ed., Alberts, B., Johnson, A., Lewis, J., and
- ▶ Enlarge, M., Garland Science (Princeton), ISBN: 0-8153-1619-4 / ISBN: 0-8153-1620-8.

3.4 Core P2 - Cell Biology Lab

Cell Biology	
	2 Credits
List of Practical	
1. Visualization of animal and plant cells by methylene blue. 2. Identification of different stages of mitosis in onion root tip. 3. Identification of different stages of meiosis in grasshopper testis/ onion flower bud anthers 4. Micrographs of different cell components and study of mitosis and meiosis from permanent slides (dry lab). 5. Sub-cellular fractionation and Visualization of nuclear fraction by acetocarmine stain. 6. Staining and visualization of mitochondria by Janus green stain.	

3.5 Core T3 - Proteins

Proteins	
	4 Credits
Introduction to amino acids, peptides and proteins	
Amino acids and their properties - hydrophobic, polar and charged. Biologically important peptides - hormones, antibiotics and growth factors. Multimeric proteins, conjugated proteins and metallo proteins. Diversity of function (Specific examples of Proteins/Peptides may be included under each category)	
Extraction, Separation and Characterization of Proteins	
Solubilization of proteins from their cellular and extracellular locations. Use of simple grinding methods, homogenization, ultrasonication, French press and centrifugation. Ammonium sulphate fractionation, solvent fractionation, dialysis and lyophilisation. Ion- exchange chromatography, molecular sieve chromatography, hydrophobic interaction/reverse phase chromatography, affinity chromatography, HPLC and FPLC Determination of purity, molecular weight, extinction coefficient and sedimentation coefficient, IEF, SDS-PAGE and 2-D electrophoresis.	
Covalent structure of proteins	
Organization of protein structure into primary, secondary, tertiary and quaternary structures.	
Three dimensional structures of proteins	
Nature of stabilizing bonds - covalent and non-covalent. Importance of primary structure in folding. The peptide bond - bond lengths and configuration. Dihedral angles psi and phi. Helices, sheets and turns. Ramachandran map. Techniques used in studying 3-D structures - X-ray diffraction and NMR (introductory). Motifs and domains.	
Protein folding and conformational diseases	

Denaturation and renaturation of Ribonuclease A. Introduction to thermodynamics of folding and molten globule. Assisted folding by molecular chaperones, chaperonins and PDI. Defects in protein folding. Diseases -Alzheimer's and Prion based.

Myoglobin and haemoglobin and Membrane Proteins

Structures of myoglobin and haemoglobin, Oxygen binding curves, influence of 2, 3-BPG, CO₂ and Cl⁻. Hill plot. Cooperativity between subunits and models to explain the phenomena - concerted and sequential models.

Haemoglobin disorders.

Integral and membrane associated proteins. Hydropathy plots to predict transmembrane domains. Significance of membrane proteins - bacteriorhodopsin.

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13: 978-1-4641-0962-1 / ISBN: 10:1-4292-3414-8.
- ▶ Physical Biochemistry (2009) 2nd ed., Sheehan, D., Wiley-Blackwell (West Sussex), **ISBN: 9780470856024 / ISBN: 9780470856031.**
- ▶ The Tools of Biochemistry (1977; Reprint 2011) Cooper, T.G., Wiley India Pvt. Ltd. (New Delhi), ISBN: 978-81-265-3016-8.
- ▶ Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4

3.6 Core P3 - Proteins Lab

Proteins	
	2 Credits
List of Practical	
1. Qualitative tests for amino acids and proteins 2. Estimation of proteins using UV absorbance and Biuret method. 3. Assay of proteins using Lowry/Bradford method, standard curve preparation. 4. Isoelectric pH of casein. 5. SDS-PAGE analysis of proteins.	

3.7 Core T4 - Enzymes

Enzymes	
	4 Credits
Introduction to enzymes	
Nature of enzymes - protein and non-protein (ribozyme). Cofactor and prosthetic group, apoenzyme, holoenzyme. IUBMB classification of enzymes.	
Features of enzyme catalysis	
Factors affecting the rate of chemical reactions, collision theory, activation energy and transition state theory, catalysis, reaction rates and thermodynamics of reaction. Catalytic power and specificity of enzymes (concept of active site), Fischer's lock and key hypothesis, Koshland's induced fit hypothesis.	
Enzyme kinetics	
Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant - monosubstrate reactions. Michaelis-Menten equation, Lineweaver- Burk plot, Eadie-Hofstee and Hanes plot. K_m and V_{max} , K_{cat} and turnover number. Effect of pH, temperature and metal ions on the activity of enzyme.	
Enzyme inhibition	
Reversible inhibition (competitive, uncompetitive, non-competitive, mixed and substrate). Mechanism based inhibitors - antibiotics as inhibitors	
Mechanism of action of enzymes	
General features - proximity and orientation, strain and distortion, acid base and covalent catalysis (chymotrypsin, lysozyme). Metal activated enzymes and metalloenzymes, transition state analogues.	
Regulation of enzyme activity	
Control of activities of single enzymes (end product inhibition) and metabolic pathways, feedback inhibition, allosteric regulation (aspartate transcarbamoylase), reversible covalent	

modification phosphorylation (glycogen phosphorylase). Proteolytic cleavage- zymogen. Multienzyme complex as regulatory enzymes. Occurrence and isolation, phylogenetic distribution and properties (pyruvate dehydrogenase, fatty acyl synthase) Isoenzymes - properties and physiological significance (lactate dehydrogenase).

Involvement of coenzymes in enzyme catalysed reactions

TPP, FAD, NAD, pyridoxal phosphate, biotin, coenzyme A, tetrahydrofolate, lipoic acid.

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13: 978-1-4641-0962-1 / ISBN: 10:1-4292-3414-8.
- ▶ Biochemistry (2011) 4th ed., Donald, V. and Judith G.V., John Wiley & Sons Asia Pvt. Ltd. (New Jersey), ISBN: 978-1180-25024.
- ▶ Fundamentals of Enzymology (1999) 3rd ed., Nicholas C.P. and Lewis S., Oxford University Press Inc. (New York), ISBN:0 19 850229 X.
- ▶ Enzymes, (1973), Malcolm Dixon, Edwin Clifford Webb, Prentice Hall Press, ISBN: 0 58 2462177
- ▶ Biochemical Calculations, (1976) 3rd ed., Irwin H. Segel, John Wiley and Sons ISBN: 0 47 1774219

3.8 Core P4 - Enzymes Lab

Enzymes	
	2 Credits
List of Practical	
1. Partial purification of alkaline phosphatase from germinating mung bean. 2. Assay of enzyme activity and specific activity of alkaline phosphatase. 3. Effect of pH on enzyme activity 4. Determination of K_m and V_{max} using Lineweaver-Burk graph. 5. Enzyme inhibition - calculation of K_i for competitive inhibition.	

3.9 Core T5 - Metabolism of Carbohydrates and Lipids

Metabolism of Carbohydrates and Lipids	
	4 Credits
Basic design of metabolism	
Autotrophs, heterotrophs, metabolic pathways, catabolism, anabolism, ATP as energy currency, reducing power of the cell.	
Glycolysis, Gluconeogenesis, pentose phosphate pathway and Glycogen metabolism	
Glycolysis - a universal pathway, reactions of glycolysis, fermentation, fates of pyruvate, feeder pathways for glycolysis, galactosemia. Synthesis of glucose from non-carbohydrate sources, reciprocal regulation of glycolysis and gluconeogenesis, pentose phosphate pathway and its importance. Glycogenesis and glycogenolysis, regulation of glycogen metabolism, glycogen storage diseases.	
Citric acid cycle	
Production of acetyl CoA, reactions of citric acid cycle, anaplerotic reactions, amphibolic role, regulation of citric acid cycle, glyoxalate pathway, coordinated regulation of glyoxalate and citric acid pathways.	
Fatty acid oxidation	
Digestion, mobilisation and transport of cholesterol and triacyl glycerols, fatty acid transport to mitochondria, β oxidation of saturated, unsaturated, odd and even numbered and branched chain fatty acids, regulation of fatty acid oxidation, peroxisomal oxidation, ω oxidation, ketone body's metabolism, ketoacidosis	
Fatty acid synthesis	
Fatty acid synthase complex. Synthesis of saturated, unsaturated, odd and even chain fatty acids and regulation.	
Biosynthesis of eicosanoids, cholesterol, steroids and isoprenoids	

Synthesis of prostagladins, leukotrienes and thromboxanes. Synthesis of cholesterol, regulation of cholesterol synthesis. Synthesis of steroids and isoprenoids.

Biosynthesis of membrane lipids

Synthesis of membrane phospholipids in prokaryotes and eukaryotes, respiratory distress syndrome, biosynthesis of triacylglycerol, biosynthesis of plasmalogens, sphingolipids and glycolipids, lipid storage diseases.

Starve-feed cycle

Well-fed state, early fasting state, fasting state, early re-fed state, energy requirements, reserves and caloric homeostasis, five phases of glucose homeostasis.

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13:978-1-4641-0962-1 / ISBN: 10:1-4641-0962-1.
- ▶ Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New Jersey), ISBN: 978-0-470-28173-4.
- ▶ Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer L., W.H. Freeman and Company (New York), ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4

3.10 Core P5 - Metabolism of Carbohydrates and Lipids Lab

Metabolism of Carbohydrates and Lipids	
	2 Credits
List of Practical	
1. Qualitative tests for carbohydrates and lipids 2. Separation of sugars by thin layer chromatography. 3. Assay of salivary amylase. 4. Isolation of cholesterol from egg yolk and its estimation. 5. Isolation of Lecithin and its estimation.	

3.11 Core T6 - Physiology and Hormones

Physiology and Hormones	
	4 Credits
Homeostasis and the organization of body fluid compartments	
Intracellular, extracellular and interstitial fluid. Homeostasis, control system and their components. Plasma as an extracellular fluid, RBC, molecular mechanism of blood coagulation, role of vitamin K in coagulation, anticoagulant and fibrinolytic systems. Anemias, polycythemia, haemophilia and thrombosis.	
Cardiovascular physiology and Respiration	
Anatomy of heart. Physiology of the cardiac muscle, automaticity of the cardiac muscle contraction, excitation contraction coupling, relationship between cardiac cycle, control of cardiac function and output. The arterial system, venous system, the microcirculation and mechanics of capillary fluid exchange. Portal circulations. Organization of the pulmonary system. Mechanism of respiration, pulmonary ventilation and related volumes, pulmonary circulation. Principles of gas exchange and transport. Regulation of respiration.	
Introduction to endocrinology	
Functions of hormones and their regulation. Chemical signalling - endocrine, paracrine, autocrine, intracrine and neuroendocrine mechanisms. Chemical classification of hormones, transport of hormones in the circulation and their half-lives.	
Thyroid hormone	
Thyroid gland. Biosynthesis of thyroid hormone and its regulation; its physiological and biochemical action. Pathophysiology - Goiter, Graves' disease, cretinism, myxedema, Hashimoto's disease.	
Hormone mediated signalling	

Hormone receptors - extracellular and intracellular. Receptor - hormone binding, Scatchard analysis. G protein coupled receptors, G proteins, second messengers - cAMP, cGMP, IP3, DAG, Ca²⁺, NO. Effector systems - adenylyl cyclase, guanylyl cyclase, PDE, PLC.

Receptor tyrosine kinases - EGF, insulin, erythropoietin receptor; raps - MAP kinase cascade, JAK - STAT pathway. Steroid hormone and thyroid hormone receptor mediated gene regulation. Receptor regulation and cross talk.

Hypothalamic and pituitary hormones

Hypothalamic - pituitary axis. Study the physiological and biochemical actions of hypothalamic hormones, pituitary hormones - GH, prolactin, TSH, LH, FSH, POMC peptide family, oxytocin and vasopressin, feedback regulation cycle.

Endocrine disorders - gigantism, acromegaly, dwarfs, pigmies and diabetes insipidus.

Pancreatic and GI tract hormones

Regulation of release of insulin, glucagon, gastrin, secretin, CCK, GIP, adipoleptin, leptin and ghrelin. Summary of hormone metabolite control of GI function. Physiological and biochemical action. Pathophysiology - diabetes type I and type II.

Hormones of adrenals

Aldosterone, renin angiotensin system, cortisol, epinephrine and norepinephrine. Fight or flight response, stress response. Pathophysiology - Addison's disease, Conn's syndrome, Cushing syndrome.

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M. W.H. Freeman & Company (New York), ISBN: 10-14641-0962- 1.
- ▶ Vander's Human Physiology (2008) 11th ed., Widmaier, E.P., Raff, H. and Strang, K.T. McGraw Hill International Publications, ISBN: 978-0-07-128366-3.
- ▶ Endocrinology (2007) 6th ed., Hadley, M.C. and Levine, J.E. Pearson Education, ISBN: 978-81-317-2610-5.
- ▶ The Cell: A Molecular Approach (2009) 5th Ed. Cooper, G.M. and Hausman, R.E. ASM Press & Sunderland, ISBN: 978-0-87893- 300-6.
- ▶ Human Physiology (2016) 11th Ed., C. C. Chatterjee, CBS Publishers, ISBN: 10- 81239 2873-4
- ▶ Biochemistry (1978) 2nd Ed., Debajyoti Das, Academic Publishers
- ▶ Medical Physiology (2010) 12 Ed., Guyton and Hall, Saunders, ISBN: 10- 14160-4574-0

3.12 Core P6 - Physiology and Hormones Lab

Physiology and Hormones	
	2 Credits
List of Practical	
1. Estimation of haemoglobin. 2. Separation of plasma proteins. 3. Separation of isoenzymes of LDH by electrophoresis. 4. Estimation of serum Ca^{2+}. 5. Estimation of serum T4.	

3.13 Core T7 - Physical Biochemistry

Physical Biochemistry	
	4 Credits
Introduction	
Special chemical requirement of biomolecules; factors affecting analyte structure and stability: pH, temperature and solvent polarity; buffering systems used in biochemistry, osmolarity and colligative properties	
Chromatography	
Principles of chromatography: partition coefficient, phase systems, liquid and gas chromatography; performance parameters: retention, resolution, basis of peak broadening, peak symmetry; chromatography equipment; modes of chromatography: ion exchange, gel filtration and affinity; HPLC	
Spectroscopy-I	
Theories of light (wave-particle duality); the electromagnetic spectrum; UV/visible absorption spectroscopy: physical basis, Beer Lambert's law, Deviations of Beer Lambert's law; transitions, Applications of UV-visible spectroscopy; UV-visible spectroscopy of proteins and nucleic acids; Fluorescence and Chemiluminescence: physical basis, measurement, quenching, protein folding studies; resonance energy transfer, applications in cell biology	
Spectroscopy-II	
Spectroscopic techniques using plane polarized light: polarized light, chirality of biomolecules, circular dichroism and linear dichroism. Infrared Spectroscopy- Modes of molecular vibrations; Vibration of a diatomic molecule; Application of Hooke's law; characteristic stretching frequencies of O-H, N-H, C-H, C-D, C=C, C=N, C=O functions; Factors affecting stretching frequencies (H-bonding, electronic factors, mass effects, bond multiplicity); Applications of infrared spectroscopy, Analysis and interpretation of IR data, FT-IR spectroscopy, Determination of secondary structure of proteins.	
Hydrodynamics and Bio calorimetry	

Viscosity: definition, measurement, dependence on characteristics of solute; sedimentation: physical basis, subcellular fractionation, sedimentation velocity and sedimentation equilibrium; thermodynamic parameters: activation energy, enthalpy, entropy and free energy

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M. W.H. Freeman & Company (New York), ISBN: 10-14641-0962- 1.
- ▶ Physical Biochemistry, Principles and Applications (2009) 2nd Ed., David Sheehan, Wiley, ISBN: 10- 04708-5603-3
- ▶ Physical Biochemistry, (1982) 2nd Ed., David Friefelder, W. H. Freeman, ISBN: 10- 07167-1444-2
- ▶ Biophysical Chemistry, Principles and Techniques (2016) 4th Ed., Upadhyay and Upadhyay, Himalaya Publishing House, ISBN: 10-93514-2227-5
- ▶ Physical Biochemistry (2005) 2nd Ed., Van Holde, Prentice Hall, ISBN: 10-01304-6427-9

3.14 Core P7 - Physical Biochemistry Lab

Physical Biochemistry	
	2 Credits
List of Practical	
1. Preparation of buffers and pH determination. 2. Determination isoelectric point of amino acids (Glycine, Glutamic acid and Histidine) 3. Study of excitation and emission spectra of proteins by spectro fluorimetry 4. Column chromatography (size exclusion, ion-exchange)	

3.15 Core T8 - Metabolism of Amino Acids and Nucleotides

Metabolism of Amino Acids and Nucleotides	
	4 Credits
Overview of amino acid metabolism	
Nitrogen cycle, incorporation of ammonia into biomolecules. Metabolic fates of amino groups. Digestion and absorption of dietary proteins. Protein calorie malnutrition - Kwashiorkar and Marasmus. Nitrogen balance, transamination, role of pyridoxal phosphate, glucose-alanine cycle, Kreb's bicycle, urea cycle and inherited defects of urea cycle.	
Catabolism of amino acids	
Catabolic pathways of individual amino acids. Glucogenic and ketogenic amino acids. Metabolism of one carbon units. Disorders of amino acids metabolism, phenylketonuria, alkaptonuria, maple syrup urine disease, methylmalonic acidemia (MMA), homocystinuria and Hartnup's disease.	
Biosynthesis of amino acids	
Overview of amino acid synthesis. Biosynthesis of non-essential amino acids and its regulation.	
Precursor functions of amino acids	
Biosynthesis of creatine and creatinine, polyamines (putresine, spermine, spermidine), catecholamines (dopamine, epinephrine, norepinephrine) and neurotransmitters (serotonin, GABA). Porphyrin biosynthesis, catabolism and disorders of porphyrin metabolism.	
Biosynthesis of purine and pyrimidine nucleotides	
De novo synthesis of purine and pyrimidine nucleotides, regulation and salvage pathways.	
Deoxyribonucleotides and synthesis of nucleotide triphosphate	
Biosynthesis of deoxyribonucleotides and its regulation, conversion to triphosphates, biosynthesis of coenzyme nucleotides	

Degradation of purine and pyrimidine nucleotides

Digestion of nucleic acids, degradation of purine and pyrimidine nucleotides. Inhibitors of nucleotide metabolism. Disorders of purine and pyrimidine metabolism - Lesch-Nyhan syndrome, Gout, SCID, adenosine deaminase deficiency.

Integration of metabolism

Integration of metabolic pathways (carbohydrate, lipid and amino acid metabolic pathways), tissue specific metabolism (brain, muscle, and liver), systems biology (introductory)

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13:978-1-4641-0962-1 / ISBN: 10:1-4641-0962-1.
- ▶ Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley&Sons, Inc. (New York), ISBN: 978-0-470-28173-4/BRV ISBN: 978-0-470- 60152 5.

3.16 Core P8 - Metabolism of Amino Acids and Nucleotides Lab

Metabolism of Amino Acids and Nucleotides	
	2 Credits
List of Practical	
1. Assay of serum transaminases - SGOT and SGPT 2. Estimation of serum urea, 3. Estimation of serum uric acid 4. Estimation of serum creatinine	

3.17 Core T9 - Membrane Biology and Bioenergetics

Membrane Biology and Bioenergetics	
	4 Credits
Introduction to biomembranes	
Composition of bio membranes - prokaryotic, eukaryotic, neuronal and subcellular membranes. Study of membrane proteins. Fluid mosaic model with experimental proof. Monolayer, planer bilayer and liposomes as model membrane systems.	
Membrane structures and dynamics	
Polymorphic structures of amphiphilic molecules in aqueous solutions - micelles and bilayers. CMC, critical packing parameter. Membrane asymmetry. Macro and micro domains in membranes. Membrane skeleton, lipid rafts, caveolae and tight junctions. RBC membrane architecture. Lateral, transverse and rotational motion of lipids and proteins. Techniques used to study membrane dynamics - FRAP, TNBS labelling etc. Transition studies of lipid bilayer, transition temperature. Membrane fluidity, factors affecting membrane fluidity.	
Membrane transport	
Thermodynamics of transport. Simple diffusion and facilitated diffusion. Passive transport - glucose transporter, anion transporter and porins. Primary active transporters - P type ATPases, V type ATPases, F type ATPases. Secondary active transporters - lactose permease, Na ⁺ -glucose symporter. ABC family of transporters - MDR, CFTR. Group translocation. Ion channels - voltage-gated ion channels (Na ⁺ /K ⁺ voltage-gated channel), ligand-gated ion channels (acetyl choline receptor), aquaporins, and bacteriorhodopsin. Ionophores - valinomycin, gramicidin.	
Vesicular transport and membrane fusion	
Types of vesicle transport and their function - clathrin, COP I and COP II coated vesicles. Molecular mechanism of vesicular transport. Membrane fusion. Receptor mediated endocytosis of transferrin, envelope virus-host cell interaction	
Introduction to bioenergetics	

Laws of thermodynamics, state functions, equilibrium constant, coupled reactions, energy charge, ATP cycle, phosphorylation potential, phosphoryl group transfers. Chemical basis of high standard energy of hydrolysis of ATP, other phosphorylated compounds and thioesters. Redox reactions, standard redox potentials and Nernst equation. Universal electron carriers.

Oxidative phosphorylation

Mitochondria. Electron transport chain - its organization and function. Inhibitors of ETC and uncouplers. Peter Mitchell's chemiosmotic hypothesis. Proton motive force. Fo F1ATP synthase, structure and mechanism of ATP synthesis. Metabolite transporters in mitochondria. Regulation of oxidative phosphorylation. ROS production and antioxidant mechanisms. Thermogenesis.

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13:978-1-4641-0962-1 / ISBN: 10:1-4641-0962-1.
- ▶ Molecular Cell Biology (2013) 7th ed., Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Scott, M.P., W.H. Freeman & Company (New York), ISBN: 13:978-1-4641-0981-2.
- ▶ Biochemistry (2010) 4th ed., Garret, R. H. and Grisham, C.M., Cengage Learning (Boston), ISBN-13:978-0-495-11464-2.
- ▶ Principles of Biochemistry (2008) 3rd ed., Voet, D.J., Voet, J.G. and Pratt, C.W., John Wiley & Sons, Inc. (New York), ISBN:13: 978-0470-23396-2

3.18 Core P9 - Membrane Biology and Bioenergetics Lab

Membrane Biology and Bioenergetics	
	2 Credits
List of Practical	
1. Effect of lipid composition on the permeability of a lipid monolayer. 2. Determination of CMC of detergents. 3. Isolation of mitochondria from liver and assay of marker enzyme SDH.	

3.19 Core T10 - Basic Microbiology and Microbial Genetics

Basic Microbiology and Microbial Genetics	
	4 Credits
Introduction	
Spontaneous generation (abiogenesis), Biogenesis, Germ Theory of Disease, Koch's Postulates, Scope of Microbiology.	
Microorganisms in biological world	
Whittaker's Five-kingdom and three-kingdom concept of living organisms (General characteristics of those groups); General features of Eubacteria and Archaeobacteria (major difference within Eubacteria).	
Staining techniques and bacterial Morphology and subcellular structures	
Definition of auxochrome; Chromophores; Acidic and Basic dyes; Classification of stains; Simple and differential staining: theories of staining, Gram staining; acid fast staining; endospore staining; mechanism of gram staining. Morphology of bacteria, Slime layer, Mycelial morphology: Actinomycetes, Capsule, Cell wall, Ribosome, Cytoplasmic membrane (Fluid mosaic model of Singer - Nicholson); Cytoplasmic inclusion bodies - (inorganic, organic); Exospores & Cysts: types & structure; Endospore, Flagella, Pilus, Fimbriae (structure, composition and functions). Bacterial cell wall biosynthesis and structure.	
Microbial Nutrition	
Nutritional types (definition and example) - Photoautotrophs, Photoorganotrophs, Chemolithotrophs (ammonia, nitrite, sulfur, hydrogen, iron oxidizing bacteria); Chemoorganotrophs, Effect of oxygen on growth - classification on the basis of oxygen requirement and tolerance.	
Bacterial Growth and its regulation	
Growth phases - Generation time. Kinetics of growth, Batch culture. Continuous culture.	

Synchronous culture (definition and brief description). Physical factors influencing growth such as temperature, pH, osmotic pressure, salt concentration.

Sterilization, disinfection, antiseptic, sanitizer, germicide, antimicrobial agent (definition, application & examples); physical method of disinfection and sterilization - dry heat, moist heat, filtration, radiation (mode of action, applications); Chemical control - dye solutions, alcohol, acid, alkali, halogen, heavy metal, phenol, phenol derivatives, formaldehyde, ethylene oxide, detergents (mode of action, applications).

Chemotherapeutic agents - sulphonamides, antibiotics, (definition types); mechanism of action and antimicrobial spectrum of penicillin, streptomycin, tetracycline, chloramphenicol, Nalidixic acid and metronidazole; drug resistance - phenomena and mechanism.

Microbial Genetics

Plasmids and episomes. Nuclear material, Bacterial Chromosome (Fundamental differences with eukaryotic chromosome). Mechanism of genetic exchange - conjugation, transformation and transduction. Gene mapping in bacteria. An introduction to viruses with special reference to the structure, replication of T4 and λ phage, lytic and lysogenic cycles.

Reference Books

- ▶ General Microbiology (1999) 5th Edition: Stanier, RY., et al., Palgrave Macmillan, ISBN-10: 0333763645/ISBN-13: 978-0333763643
- ▶ Microbiology 5th edition (2001): Pelczar. M., et al., Tata-McGraw Hill ISBN-10: 0074623206/ISBN-13: 978-0074623206
- ▶ Principles of Microbiology 2nd edition(1997): Atlas, RM., McGraw-Hill, ISBN-10: 9339219872/ISBN-13: 978-9339219871
- ▶ Fundamental principles of bacteriology (1999): Salle, AJ.,Tata- McGraw Hill, ISBN: 9781406707373/ 1406707376
- ▶ Microbiology 6th Edition (2004): Prescott Lansing M. et al. McGraw Hill Higher Education ISBN-10: 0072951753/ ISBN-13: 978-0072951752

3.20 Core P10 - Basic Microbiology and Microbial Genetics Lab

Basic Microbiology and Microbial Genetics	
	2 Credits
List of Practical	
1. Microbiology Laboratory Practices and Biosafety. 2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) 3. Preparation and sterilization of culture media for bacterial cultivation 4. Study of different shapes of bacteria, fungi, algae, protozoa using permanent slides/pictographs 5. Staining of bacteria using Gram stain 6. Isolation of pure cultures of bacteria by streaking method.	

3.21 Core T11 - Gene Expression and Regulation

Gene Expression and Regulation	
	4 Credits
Biosynthesis of RNA in prokaryotes	
RNA polymerases, transcription cycle in bacteria, sigma factor, bacterial promoters, identification of DNA binding sites by DNA foot printing, the three stages of RNA synthesis, initiation, elongation and termination, rho-dependent and rho-independent termination. Inhibitors of transcription and applications as anti-microbial drugs.	
The genetic code	
Degeneracy of the genetic code, wobble in the anticodon, features of the genetic code, nearly universal code.	
Biosynthesis of proteins	
Messenger RNA, transfer RNA, attachment of amino acids to tRNA, the ribosome - initiation, elongation and termination of translation, regulation of translation. Comparison of prokaryotic and eukaryotic protein synthesis. Use of antibiotics in understanding protein synthesis and applications in medicine.	
Regulation of gene expression in prokaryotes	
Principles of gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, DNA binding domains, regulation of lac operon and trp operon, induction of SOS response, synthesis of ribosomal proteins, regulation by genetic recombination, transcriptional regulation in λ bacteriophage.	
Mendel's principles & chromosomal basis of heredity and Extensions of Mendelism	
Mendel's law of inheritance, Laws of probability & binomial expansion, formulating and testing genetic hypothesis, chromosome theory of inheritance. Allelic variation and gene function - dominance relationships, multiple alleles, lethal alleles and null alleles. Pleiotropy gene interaction - epistatic and non-epistatic, interaction between gene(s) and environment. Penetrance and expressivity, pleiotropy and phenocopy.	

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman & Company (New York), ISBN: 13: 978-1-4292-3414-6 / ISBN: 10-14641-0962-1.
- ▶ Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York), ISBN:0-321-50781 / ISBN: 978-0-321-50781-5.
- ▶ Lewin's GENES (2013) 11th Ed., Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning, ISBN: 10- 14496-5985-3
- ▶ A Text Book of Molecular Biology (2009): Sastri Sivarama, Padmanaban G and Subramanyam C. Macmillan Publishers India ISBN-10: 0333929330/ISBN-13: 978-0333929339
- ▶ Biochemistry (2015): Berg, Jeremy M., Tymoczko, John L., Gatto, Gregory J. Jr., and Stryer, Lubert, W H Freeman & Co (Sd); ISBN-10: 1319036813/ ISBN-13: 978-1319036812
- ▶ DNA Structure and Function(2006): Sinden Richard, CBS Publishers and Distributors, ISBN-10: 8131203255/ ISBN-13: 978-8131203255
- ▶ Genetics (2012) 6th Ed., Snustad, D.P. And Simmons, M.J., John Wiley & Sons. (Singapore), ISBN: 978-1-118-09242-2.
- ▶ Genetics - A Conceptual Approach (2012), 4th ed., Pierce, B.A., W.H. Freeman & Co. (New York), ISBN: 13:978-1-4292-7606-1 / ISBN: 10:1-4292-7606-1.
- ▶ An Introduction to Genetic Analysis (2010), 10th ed., Griffiths, A.J.F, Wessler, S. R, Carroll, S. B. and Doebley, J., W.H. Freeman & Company (New York), ISBN: 10: 1- 4292-2943-8.

3.22 Core P11 - Gene Expression and Regulation Lab

Gene Expression and Regulation	
	2 Credits
List of Practical	
7. Extraction of total nucleic acids from bacterial cells and quantitative estimation of DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A260 measurement). 8. Concept of standard curve and estimation of unknown DNA concentration using Salmon sperm/calf thymus DNA. 9. Preparation of culture medium (LB) for E.coli (both solid and liquid) and raise culture of E.coli and demonstration of antibiotic resistance. (Culture of E.coli containing plasmid (pUC 18/19) in LB medium with/without antibiotic pressure and interpretation of results). 10. Diauxic growth curve effect. 11. Induction of lac operon and enzyme assay (beta-galactocidase assay).	

3.23 Core T12 - Gene Organization, Replication and Repair

Gene Organization, Replication and Repair	
	4 Credits
Structure of DNA	
DNA structure, features of the double helix, various forms of DNA, denaturation and re association of DNA.	
Genes and genomic organization	
Definition of a gene, organization of genes in viruses, bacteria, eukaryotes. Nucleosome structure and packaging of DNA into higher order structures.	
Replication of DNA	
The chemistry of DNA synthesis, DNA polymerase, the replication fork, origin of replication, enzymes and proteins in DNA replication, various modes of replication, stages of replication of E. coli chromosome. Inhibitors of DNA replication and applications in medicine. Supercoiling of DNA and its importance, topoisomerase inhibitors and their application in medicine.	
Recombination and transposition of DNA	
Homologous recombination, proteins and enzymes in recombination, site-specific recombination, serine and tyrosine recombinases, biological roles of site-specific recombination, transposition, three classes of transposable elements, importance of transposable elements in horizontal transfer of genes and evolution	
Molecular basis of mutations	
Importance of mutations in evolution of species. Types of mutations - transition, transversions, frame shift mutations, Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations, Molecular basis of Mutations in relation to UV light and chemical mutagens, Ames test.	
Various modes of DNA repair	

Replication errors and mismatch repair system, repair of DNA damage, direct repair, base excision repair, nucleotide excision repair, recombination repair, SOS Repair.

Reference Books

- ▶ Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold spring Harbor (New York), ISBN: 0-321-50781 / ISBN: 978-0-321-50781-5.
- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W. H. Freeman & Company (New York), ISBN: 13: 978-1-4292-3414-6 / ISBN: 10-14641-0962-1.
- ▶ Principles of Genetics (2010) 5th ed., Snustad, D.P. and Simmons, M.J., John Wiley & Sons Asia, ISBN: 978-0-470-39842-5.
- ▶ A Text Book of Molecular Biology (2009): Sastri Sivarama, Padmanaban G and Subramanyam C., Macmillan Publishers India ISBN-10: 0333929330/ISBN-13: 978-0333929339

3.24 Core P12 - Gene Organization, Replication and Repair Lab

Gene Organization, Replication and Repair	
	2 Credits
List of Practical	
1. Verification of Chargaff's rule by paper chromatography. 2. Determination of the melting temperature and GC content of DNA. 3. Study of viscosity of DNA solutions. 4. Agarose gel electrophoresis and estimation of DNA size by using markers 5. To perform Ames test in Salmonella/E.coli to study mutagenicity	

3.25 Core T13 - Recombinant DNA Technology and Genetic Engineering

Recombinant DNA Technology and Genetic Engineering	
	4 Credits
Introduction to recombinant DNA technology	
Overview of recombinant DNA technology. Restriction and modification systems, restriction endonucleases and other enzymes used in manipulating DNA molecules (DNA polymerases, RNA Polymerases, Reverse Transcriptase, Ligases, Taq polymerase, Kinases), separation of DNA by gel electrophoresis. Extraction and purification of plasmid and bacteriophage DNA.	
Cloning vectors for prokaryotes and eukaryotes	
Plasmids, classification, copy number and its regulation, incompatibility and curing, Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors based on E. coli plasmids, pBR322, pUC8, pGEM3Z. Cloning vectors based on M13 and λ bacteriophage. The problem of selection, direct selection, marker rescue. Gene libraries, identification of a clone from gene library, colony and plaque hybridization probing, methods based on detection of the translation product of the cloned gene. Ligation of DNA molecules. DNA ligase, sticky ends, blunt ends, linkers and adapters. Synthetic oligonucleotides, synthesis and use.	
Introduction of DNA into cells and selection for recombinant clones	
Uptake of DNA by cells, preparation of competent cells. Selection for transformed cells. Identification for recombinants - Sequence dependent and independent screening, southern-western, colony and plaque hybridization, insertional inactivation, blue-white selection. Introduction of phage DNA into bacterial cells. Identification of recombinant phages.	
Expression of cloned genes	
Vectors for expression of foreign genes in E. coli, cassettes and gene fusions. Challenges in producing recombinant protein in E. coli.	

Polymerase chain reaction

Fundamentals of polymerase chain reaction, designing primers for PCR. Studying PCR products. Cloning PCR products. Quantitative PCR.

DNA sequencing

DNA sequencing by Sanger's method, modifications based on Sanger's method. Automated DNA sequencing. Pyrosequencing and Next Generation Sequencing

Applications of genetic engineering in Biotechnology

Applications in medicine, production of recombinant pharmaceuticals such as insulin. Recombinant vaccines. Gene therapy. Applications in agriculture - plant genetic engineering, herbicide resistant crops, problems with genetically modified plants, safety concerns.

Reference Books

- ▶ Gene Cloning and DNA Analysis (2010) 6th ed., Brown, T.A., Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
- ▶ Principles of Gene Manipulation and Genomics (2006) 7th ed., Primrose, S.B., and Twyman, R. M., Blackwell publishing (Oxford, UK) ISBN:13: 978-1-4051-3544-3.
- ▶ Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) 4th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC), ISBN: 978-1-55581-498-4 (HC).
- ▶ Recombinant DNA: Genes and Genomes 3rd edition (2007): Watson, James D., et all. W.H. Freeman ISBN-10: 1429203129/ISBN-13: 978-1429203128

3.26 Core P13 - Recombinant DNA Technology and Genetic Engineering Lab

Recombinant DNA Technology and Genetic Engineering	
	2 Credits
List of Practical	
1. Isolation of plasmid DNA from E. coli cells. 2. Digestion of plasmid DNA with restriction enzymes and size estimation of fragments by gel electrophoresis. 3. Preparation of competent cells, transformation and estimation of transformation efficiency 4. Designing of primers for any selected gene and demonstration of PCR technique. 5. Plaque assay and determination of phage titre	

3.27 Core T14 - Immunology

Immunology	
	4 Credits
Cells and organs of the immune system	
Hematopoiesis, cells of the immune system, primary and secondary lymphoid organs and tissues (MALT).	
Innate immunity	
Anatomical barriers, cell types of innate immunity, soluble molecules and membrane associated receptors (PRR), connections between innate and adaptive immunity, cell adhesion molecules, chemokines.	
Immunogens and antigens	
Antigens and haptens, factors that dictate immunogenicity, B and T cell epitopes. Structure and distribution of classes and subclasses of immunoglobulins (Ig), Ig fold, effector functions of antibody, antigenic determinants on Ig and Ig super family, antigen-antibody interaction	
Biology of the B and T lymphocyte	
Antigen independent phase of B cell maturation and selection, humoral response - T-dependent and T-independent response, anatomical distribution of B cell populations. Structure and role of T cell receptor, and co-receptor, T cell development, generation of receptor diversity, selection and differentiation. General properties of effector T cells, cytotoxic T cells (Tc), natural killer cells; NKT cells and antibody dependent cellular cytotoxicity (ADCC).	
Generation of antibody diversity	
Dreyer-Bennett hypothesis, multigene organization of Ig locus, mechanism of V region DNA rearrangement, ways of antibody diversification.	
MHC complex and antigen presentation	

General organization and inheritance of MHC, structure, distribution and role of MHC class I and class II proteins, linkage disequilibrium, pathways of antigen processing and presentation, complement activation and its biological consequences

Tolerance, autoimmunity and hypersensitivity

Organ specific and systemic autoimmune diseases, possible mechanisms of induction of autoimmunity, Gell and Coombs classification, IgE mediated (Type I) hypersensitivity, antibody mediated cytotoxic (Type II) hypersensitivity, immune complex mediated (type III) hypersensitivity and delayed type (Type IV) hypersensitivity.

Reference Books

- ▶ Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A., W.H Freeman and Company (New York), ISBN: 13: 978-0-7167-8590-3 / ISBN: 10:0-7617-8590-0.
- ▶ Immunology: A Short Course (2009) 6th ed., Coico, R and Sunshine, G., John Wiley& sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.
- ▶ Janeway's Immunobiology (2012) 8th ed., Murphy, K., Mowat, A., and Weaver, C.T., Garland Science (London & New York), ISBN: 978-0-8153-4243-4.

3.28 Core P14 - Immunology Lab

Immunology Lab	
	2 Credits
List of Practical	
1. Blood smearing and differential leukocyte and total leukocyte counting 2. Assays based on agglutination reactions - Blood typing (active) & passive agglutination. 3. Assays based on precipitation reactions - Ouchterlony double diffusion (ODD) and Mancini radial immunodiffusion. 4. Enzyme linked immune-sorbent assay (ELISA).	

4. Department Specific Electives Subjects Syllabus

4.1 DSE T1 - Nutritional Biochemistry

Nutritional Biochemistry	
Compulsory Elective	4 Credits
Introduction to Nutrition and Energy Metabolism	
Defining Nutrition, role of nutrients. Unit of energy, Biological oxidation of foodstuff. measurement of energy content of food, Physiological energy value of foods, SDA. Measurement of energy expenditure. Direct and Indirect Calorimetry, factors affecting thermogenesis, energy utilization by cells, energy output - Basal and Resting metabolism, physical activity, factors affecting energy input - hunger, appetite, energy balance Energy expenditure in man. Estimating energy requirements, BMR factors Recommended Nutrient Intakes (RNI) and Recommended Dietary Allowances for different age groups.	
Dietary carbohydrates and health	
Review functions of carbohydrates. Digestion, absorption, utilization and storage, hormonal regulation of blood glucose. Dietary requirements and source of carbohydrates, Dietary fibre, role of fibre in lipid metabolism, colon function, blood glucose level and GI tract functions.	
Dietary lipid and health	
Review of classification, sources, functions, digestion, absorption, utilization and storage. Essential Fatty Acids; Functions of EFA, RDA, - excess and deficiency of EFA. Lipotropic factors, role of saturated fat, cholesterol, lipoprotein and triglycerides. Importance of the following: a) Omega - fatty acids. Omega 3/ omega 6 ratio b) Phospholipids c) Cholesterol in the body d) Mono, Polyunsaturated and Saturated Fatty Acids. Dietary implications of fats and oils, Combination ratios of n6 and n3, MUFA, PUFA and SFA.	
Dietary Proteins and health	
Review of functions of proteins in the body, Digestion and absorption. Essential and Non- essential amino acids. Amino Acid Availability Antagonism, Toxicity and Imbalance, Amino acid Supplementation. Effects of deficiency. Food source and Recommended Dietary Allowances for	

different age group. Amino acid pool. NPU, Biological Value, Nitrogen balance. Protein calorie malnutrition and Kwashiorkor.

Fat and water soluble Vitamins

Vitamin A, C, E, K and D Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME), Deficiency. Role of Vitamin A as an antioxidant, in Visual cycle, dermatology and immunity. Role of Vitamin K in Gamma carboxylation. Role of Vitamin E as an antioxidant. Extra-skeletal role of Vitamin D and its effect on bone physiology. Hypervitaminosis. Vitamin C role as cofactor in amino acid modifications. Niacin- Metabolic interrelation between tryptophan, Niacin and NAD/ NADP. Vitamin B6-Dietary source, RDA, conversion to Pyridoxal Phosphate. Role in metabolism, Biochemical basis for deficiency symptoms. Vitamin B12 and folate; Dietary source, RDA, absorption, metabolic role Biochemical basis for deficiency symptoms.

Minerals

Calcium, Phosphorus and Iron - Distribution in the body digestion, Absorption, Utilization, Transport, Excretion, Balance, Deficiency, Toxicity, Sources, RDA. Calcium: Phosphorus ratio, Role of iron in prevention of anemia. Iodine and iodine cycle. Iodine, Fluoride, Mg, Cu, Zn, Se, Manganese, Chromium, Molybdenum Distribution in the human body, Physiology, Function, deficiency, Toxicity and Sources with special reference to Arsenic

Assessment of Nutritional status

Anthropometric measurements; Z scores, BMI, skinfold, circumference ratios. Biochemical assessment; Basal metabolic panel, Comprehensive metabolic panel, CBC, Urine Analysis, Assessment of Anemia, ROS assessment, GTT and glycosylated Hb, Differential diagnosis of B12 and folate.

Food and drug interactions and Nutraceuticals

Nutrient interactions affecting ADME of drugs, Alcohol and nutrient deficiency, Anti-depressants, psychoactive drugs and nutrient interactions, Appetite changes with drug intakes and malnutrition. Food as medicine.

Reference Books

- ▶ Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
- ▶ Nutrition for health, fitness and sport (2013); Williams.M.H, Anderson, D.E, Rawson, E.S. McGraw Hill international edition. ISBN-978-0-07-131816-7.

- ▶ Krause's Food and Nutrition Care process. (2012); Mahan, L.K. & Raymond, S.E. Elsevier's Publications. ISBN- 978-1-4377-2233-8.
- ▶ The vitamins, Fundamental aspects in Nutrition and Health (2008); G.F. Coombs Jr. Elsevier's Publications. ISBN-13- 978-0-12- 183493-7.
- ▶ Principles of Nutritional Assessment (2005) Rosalind Gibson. Oxford University Press.
- ▶ Biochemistry (2010) 14th edition: Das, Debajyoti. Academic Publishers (Kolkata), ISBN: 9789380599175, 938059917X

4.2 DSE P1- Nutritional Biochemistry Lab

Nutritional Biochemistry	
	2 Credits
List of Practical	
1. Bioassay for vitamin B12/B1. 2. Homocystiene estimation. 3. Anthropometric identifications for Kwashiorkor, Marasmus and Obesity. 4. Determination of oxidative stress: TBARS, antioxidant enzymes in hemolysate. 5. Vitamin A/E estimation in serum.	

4.3 DSE T2 - Concept of Genetics

Concept of Genetics	
	4 Credits
Introduction to Genetics	
Mendel's work on transmission of traits, Genetic Variation, Molecular basis of Genetic Information.	
Mitosis and Meiosis	
Interrelation between the cell structure and the genetics function, Mitosis, Meiosis	
Mendelian Genetics and its Extension	
Principles of Inheritance, Chromosome theory of inheritance, Laws of Probability, Pedigree analysis, Incomplete dominance and codominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Environmental effects on phenotypic expression, sex linked inheritance.	
Linkage, Crossing Over and Chromosomal Mapping	
Linkage and crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and coincidence,	
Sex Determination	
Chromosomal mechanisms, Environmental factors effecting sex determination, Barr bodies, Dosage compensation.	
Extrachromosomal Inheritance	
Organelle heredity, Chloroplast mutation/Variegation in Four o' clock plant and Chlymodomonas, Mitochondrial mutations in Neurospora and yeast, Maternal effects, Infective heredity- Kappa particles in Paramecium.	
Chromosomal aberrations	

Variations in chromosome number- monosomy and trisomy of sex and autosomes. Variations in chromosome structure - inversions, deletions, duplications and translocations.

Population genetics

Hardy-Weinberg law, predicting allele and genotype frequencies and exceptions to Hardy-Weinberg principle.

Reference Books

- ▶ Genetics (2012) 6th ed., Snustad, D.P. And Simmons, M.J., John Wiley & Sons. (Singapore), ISBN: 978-1-118-09242-2.
- ▶ Genetics - A Conceptual Approach (2012), 4th ed., Pierce, B.A., W.H. Freeman & Co. (New York), ISBN: 13:978-1-4292-7606-1 / ISBN: 10:1-4292-7606-1.
- ▶ An Introduction to Genetic Analysis (2010), 10th ed., Griffiths, A.J.F, Wessler, S. R, Carroll, S. B. and Doebley, J., W.H. Freeman & Company (New York), ISBN: 10: 1- 4292-2943-8.
- ▶ Concepts of Genetics (2016) 10th edition: Klug, William S., Cummings Michael R. and Spencers Charlotte A. Pearson Education India, ISBN-10: 9332577463/ISBN-13: 978-9332577466
- ▶ iGenetics: A Molecular Approach (2016): Russel Peter J. Pearson Education India, ISBN-10: 9332571627/ISBN-13: 978-9332571624

4.4 DSE P2 - Concept of Genetics Lab

Concept of Genetics	
	2 Credits
List of Practical	
1. Squash preparation of salivary glands of Dipteran/Drosophila larva to observe polytene chromosomes. 2. Induction of polyploidy in onion roots. 3. Smear technique to demonstrate sex chromosome in buccal epithelial cells. 4. Chi-square and probability, Linkage, recombination, gene mapping using marker based data from Drosophila, pedigree analysis of some human inherited traits; abnormal human karyotype and pedigrees, study of Hardy-Weinberg Law using simulations (dry lab)	

4.5 DSE T3 - Infectious and Non-Infectious Diseases

Infectious and Non-Infectious Diseases	
	4 Credits
Classification of infectious agents	
Bacteria, Viruses, protozoa and fungi. Source, reservoir and transmission of pathogens, Antigenic shift and antigenic drift. Host parasite relationship, types of infections associated with parasitic organisms. Overview of viral and bacterial pathogenesis. Infection and evasion.	
Overview of diseases caused by infectious agents	
Detailed study of tuberculosis: History, causative agent, molecular basis of host specificity, infection and pathogenicity, Diagnostics, Therapeutics, inhibitors and vaccines. Drug resistance and implications on public health.	
Other bacterial diseases including Typhoid, Diphtheria, Pertussis, Tetanus, Typhoid and Pneumonia. Viral diseases including AIDS, hepatitis, influenza and polio: causative agents, Pathogenesis; Detailed study of Malaria, history, causative agents, Vectors, life cycle, Host parasite interactions, Diagnostics, Drugs and Inhibitors, Resistance, Vaccine development. Other diseases including leishmaniasis, amoebiasis, Aspergillosis	
Lifestyle disorders	
The factors and biochemistry underlying Diabetes and related complications: the influence of genetics and environment on the condition and management	
Cancer	
Cancer: characteristics of a transformed cell, causes and stages of Cancer, molecular basis for neoplastic growth and metastasis, Proto-oncogenes and tumor suppressor genes; Cancer causing mutations; Tumor viruses; Biochemical analysis of cancer;	
Other diseases	

Introduction to protein folding and proteasome removal of misfolded proteins; etiology and molecular basis for Alzheimer's, Prion diseases, Huntington's Chorea, sickle cell anemia, Thalassemia.

Nutritional disorders: overview of major and minor nutrient components in the diet. Balanced diet and the concept of RDA. Nutrient deficiencies; Kwashiorkor and Marasmus, Scurvy, beri, pellagra and B12 deficiency, Xerophthalmia and Night blindness, Vitamin D deficiency, Vitamin K deficiency. Discuss with relation to biochemical basis for symptoms

Reference Books

- ▶ Prescott, Harley, Klein's Microbiology (2008) 7th Ed., Willey, J.M., Sherwood, L.M., Woolverton, C.J. Mc Graw Hill International Edition (New York) ISBN: 978-007 126727.
- ▶ Mandell, Douglas and Bennett.S, Principles and practices of Infectious diseases, 7th edition, Volume, 2. Churchill Livingstone Elsevier.
- ▶ Sherris Medical Microbiology: An Introduction to Infectious Diseases by Kenneth J. Ryan, C. George Ray, Publisher: McGraw-Hill
- ▶ Medical Microbiology by Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller, Elsevier Health Sciences
- ▶ Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
- ▶ Introduction to Human Physiology (2013) 8th edition; Lauralee Sherwood. Brooks/Cole, Cengage Learning.
- ▶ Genetics (2012) Snustad and Simmons,
- ▶ Cooper, G.M. and Hausman, R.E. 2009 the Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
- ▶ Guyton & Hall Textbook of Medical Physiology (2016) Second Edition: Hall, John E., Vaz, Mario, Kurpad, Anura, and Raj Tony. Elsevier Health, ISBN-10: 8131244660/ ISBN-13: 978-8131244661

4.6 DSE P3 - Infectious and Non-Infectious Diseases Lab

Infectious and Non-Infectious Diseases	
	2 Credits
List of Practical	
1. Identification of bacterial contamination from water, soil and food products 2. Estimation of CFU from water and soil samples 3. Estimation of blood glucose and glycosylated haemoglobin 4. Permanent slides (histology and cytology) for different types of cancer	

4.7 DSE T4 - Advanced Biochemistry

Advanced Biochemistry	
Compulsory Elective	4 Credits
Photosynthesis	
General Features of Photophosphorylation, Light Absorption, The Central Photochemical Event: Light-Driven Electron Flow, ATP Synthesis by Photophosphorylation, The Evolution of Oxygenic Photosynthesis	
Carbohydrate Biosynthesis in Plants and Bacteria	
Photosynthetic Carbohydrate Synthesis, Photorespiration and the C4 and CAM Pathways, Biosynthesis of Starch and Sucrose, Synthesis of Cell Wall Polysaccharides: Plant Cellulose and Bacterial Peptidoglycan, Integration of Carbohydrate Metabolism in the Plant Cell	
Biomolecular interaction	
Molecular interaction mechanisms and forces between molecules: selectivity, affinity, kinetics and thermodynamics. The effect of the environment on interactions. Structure and dynamics of bio macromolecules and their complexes: selectivity, multivalency, avidity. Various types of biomolecular interactions: protein-ligand, protein-protein, DNA-protein. Inhibition of interactions. Application of molecular interaction analysis in life science research, drug discovery and diagnostics	
Reference Books	
▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13: 978-1-4641-0962-1 / ISBN: 10:1-4292-3414-8. ▶ Biochemistry (2015): Berg, Jeremy M., Tymoczko, John L., Gatto, Gregory J. Jr., and Stryer, Lubert, W H Freeman & Co (Sd); ISBN-10: 1319036813/ ISBN-13: 978-1319036812	

4.8 DSE P4 - Advanced Biochemistry Lab

Advanced Biochemistry Lab	
	2 Credits
List of Practical	
1. Separation of photosynthetic pigments by TLC 2. Spectrophotometric quantitation of protein (Lowry) and preparation of standard curve. 3. Absorption spectrum of haemoglobin and determination of concentration and extinction coefficient 4. Sequence retrieval and download, visualization by molecular viewer, secondary structure prediction and homology modelling 5. Modelling of interactions by structural information and molecular graphics.	

4.9 DSE T5 - Neuro biochemistry

Neuro biochemistry	
	6 Credits
Chemical composition of brain	
Formation, structure and biochemistry of myelin, chemistry of major brain lipids, developmental changes, lipid composition, biosynthesis and catabolism of major lipids, characteristics of brain lipids, regional variations. Energy metabolism-normal oxygen consumption by the brain, energy demanding functions, role of cerebral circulation, local cerebral blood flow and metabolism, effects of glucose deprivation, influence of age and development on cerebral energy metabolism; Chemistry, synthesis, storage and release of nervous neurotransmitters, transmitter action, synaptic modulation and mechanism of neural integration.	
Neuromorphology and neurocellular anatomy	
Central nervous system-General features of neurons. Structural aspects of neuron dendrites, axons, neurotubules, neurofilaments, synapse neuralgia, astrocytes, oligodendrocytes, epenchymal cells, schwa cells. Peripheral nervous system-muscle, nerve endings, sensory receptors and effectors endings, peripheral nerves, spinal and cranial nerves, plexuses ganglia, afferent pathways and sense organs. Spinal cord-Topographical anatomy, spinal nerves, spinal meninges, joint reflexes, gray and white matter of spinal cord.	
Neurophysiology	
Neural membrane, excitability, ion channels and transport of ions. Structure function correlation at the synapse; Transmission across the synapse: membrane potential in the steady state, action potential generation and propagation; Presynaptic events at the neuromuscular junction: cholinergic and non-cholinergic synapses; EEG patterns. Neuronal membrane excitability, ion channels and transport of ions; Sensory transduction and the visual system, role of cGMP and Ca² signaling pathway	
Brain disorders	
Disorders of metabolism of brain: biochemical aspects of muscle diseases, sphingolipidosis and other lipid disorders; diseases involving myelin classification, and biochemistry of demyelinating	

diseases; Biochemical pathology of vitamin and nutritional deficiencies in brain, neurotoxic agents.
Neurodegenerative disorders;

Parkinson's and Alzheimer's disease, senile dementia

Reference Books

- ▶ Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology (Eighth Edition) by Scott Brady (Editor), George Siegel (Editor), R. Wayne Albers (Editor), Donald Price (Editor), Academic Press.
- ▶ Neurobiology 3rd Edition(2002): Smith C. U. M. Wiley, ISBN-10: 0471560383/ISBN-13: 978-0471560388
- ▶ Neuro-anatomy 5th edition (2014): Crossman Alan R., and Neary David, Churchill Livingstone, ISBN-10: 0702054054/ISBN-13: 978-0702054051

4.10 DSE T6 - Molecular Diagnostics

Molecular Diagnostics	
	4 Credits
Introduction To Biochemical Diagnostics	
Evaluation of biochemical changes in diseases, basic hepatic, renal and cardiovascular physiology; Biochemical symptoms associated with disease and their evaluation; Diagnostic biochemical profile. Inborn errors of metabolism.	
Diagnostic Enzymes	
Principles of diagnostic enzymology; Clinical significance of aspartate aminotransferase, alanine aminotransferase, creatine kinase, aldolase, lactate dehydrogenase, enzyme tests in determination of myocardial infarction, enzymes of pancreatic origin and biliary tract.	
Immunodiagnosics	
Introduction, antigen-antibody binding and assays; Immunoassays -types [RIA, ELISA, Chemiluminescent IA, FIA] and specific applications; Immunohistochemistry -principle and techniques. Immunodiagnosics for detection of infectious agents, cancer, and autoimmune diseases; Immunosensors.	
Molecular Diagnostics	
Introduction to DNA based diagnostic techniques; Polymerase chain reaction in diagnostics and analysis; Analysis of DNA in forensic science and archaeology. Applications of DNA finger printing, Techniques of chromosome analysis Chromosome preparation from cultured lymphocytes, cell lines and solid tumors Karyotyping, chromosome banding and fluorescence In-situ hybridization techniques Disease identification and Genetic tests for following disorders: Thalassemia, Fanconi anemia, Sickle Cell anemia, Fragile-X syndrome, Down Syndrome, Duchenne Muscular Dystrophy/Becker's Muscular Dystrophy, Sex-linked inherited disorders, Allelic susceptibility test for multifactorial disorders (Neural Tube Defect, Cleft Lip and Palate, Cardio Vascular Disorder, Male infertility)	
Reference Books	

- ▶ Medical Laboratory Technology - a Procedure Manual for Routine Diagnostic Tests Vol. I (2010), Mukherjee, K.L., Tata Mc Graw-Hill Publishing Company Limited (New Delhi). ISBN:9780070076594 / ISBN:9780070076631
- ▶ Medical Biochemistry (2005) 2nd ed., Baynes, J.W. and Dominiczak, M.H., Elsevier Mosby Ltd. (Philadelphia), ISBN:0-7234-3341-0.
- ▶ Recombinant DNA: Genes and Genomes 3rd edition (2007): Watson, James D., et all. W.H. Freeman ISBN-10: 1429203129/ISBN-13: 978-1429203128
- ▶ Experimental Biochemistry: A Student Companion(2005), Rao, Sashidhar B., and Deshpande, Vijay M., I K International Publishing House Pvt. Ltd ISBN-10: 8188237418/ ISBN-13: 978-8188237418
- ▶ Harpers Illustrated Biochemistry (2015) 30th edition, Rodwell Victor W, Bender David A., Botham Kathleen M., Kennely Peter J., and Weil P. Anthony, Mcgraw Hill Education, ISBN-13: 978-0071825344/ ISBN-10: 0071825347

4.11 DSE P6 - Molecular Diagnostics Lab

Molecular Diagnostics	
	2 Credits
List of Practical	
1. Gram staining and acid fast staining 2. Dot Blot ELISA for insulin 3. Lipid profile: triglycerides and total cholesterol. 4. Permanent slides (histology/cytology) for different types of cancer and comparison with slides from normal tissues 5. Permanent slides of pathogens: Plasmodium vivax and P. falciparum	

4.12 DSE T7 - Research Project

Research Project	
	6 Credits
Unit 1	
This paper would focus on the project work / dissertation to be carried out by the students in the supervision of the teachers in the colleges. The topic of the project would be selected by each student in consultation with the teacher (Advisor). This would train the student to retrieve the literature and collate the information sufficient to make a powerpoint presentation, the collated literature would also prepare the base for initiating the research. The student would carry out experiments to achieve the planned objectives, collation and analysis of data, presentation of the result in the form of a Dissertation. The grading would be based on continuous evaluation that would include punctuality, hard work, record keeping, intellectual inputs, data presentation, interpretation etc.	

5.Skill Enhancement Subjects Syllabus

5.1 SEC T1 -Techniques in Biochemistry

Techniques in Biochemistry	
	2 Credits
Basic Lab Practices and preparation of solutions	
Safety practices in the laboratory. Preparation and storage of solutions. Concepts of solution concentration and storing solutions. Quantitative transfer of liquids. Concept of a buffer, Henderson-Hasselbach equation, working of a pH meter. Exercise: Preparation of a buffer of given pH and molarity.	
Spectrophotometric techniques	
Principle and instrumentation of UV-visible and fluorescence spectroscopy. Exercises - Determination of the absorption maxima and molar extinction coefficient (of a relevant organic molecule) - Measurement of fluorescence spectrum. - Determination of concentration of a protein solution by Lowry/BCA method.	
Introduction and importance of virtual labs in biochemistry	
Reference Books	
▶ Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN: 978-0-470-85602-4 / ISBN: 978-0-470-85603-1. ▶ Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder, D., W.H. Freeman and Company (New York), ISBN: 0-7167-1315-2 / ISBN: 0-7167-1444-2. ▶ An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN: 13: 978-0-07-099487-4 / ISBN: 10: 0-07-099487-0.	

5.2 SEC T2 - Protein Purification Techniques

Protein Purification Techniques	
	2 Credits
Purification and characterization of a protein from a complex mixture (native or heterologously expressed) involving the following methods/techniques	
Exercises - Preparation of the sample. - Ion-exchange chromatography. - Gel filtration chromatography. - Affinity chromatography. - Electrophoresis.	
Demonstration of High Performance Liquid Chromatography (HPLC)	
Reference Books	
▶ Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN: 978-0-470-85602-4 / ISBN: 978-0-470-85603-1. ▶ Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder, D., W.H. Freeman and Company (New York), ISBN: 0-7167-1315-2 / ISBN: 0-7167-1444-2. ▶ An Introduction to Practical Biochemistry (1998) 3rd ed., Plummer D. T., Tata McGraw Hill Education Pvt. Ltd. (New Delhi), ISBN: 13: 978-0-07-099487-4 / ISBN: 10: 0-07-099487-0.	

5.3 SEC T3 - Clinical Biochemistry

Clinical Biochemistry	
	2 Credits
Introduction	
Organization of clinical laboratory, Introduction to instrumentation and automation in clinical biochemistry laboratories safety regulations and first aid. General comments on specimen collection, types of specimen for biochemical analysis. Precision, accuracy, quality control, precautions and limitations.	
Exercises - Collection of blood and storage. - Separation and storage of serum. - Analysis of Cell Morphology	
Evaluation of biochemical changes in diseases	
Basic hepatic, renal and cardiovascular physiology. Biochemical symptoms associated with disease and their evaluation. Diagnostic biochemical profile.	
Assessment of glucose metabolism in blood	
Clinical significance of variations in blood glucose. Diabetes mellitus. Exercise: Estimation of blood glucose by glucose oxidase peroxidase method.	
Lipid profile	
Composition and functions of lipoproteins. Clinical significance of elevated lipoprotein. Exercise: Estimation of triglycerides.	
Liver function tests	
Exercise: Estimation of bilirubin (direct and indirect).	
Renal function tests and urine analysis	

Use of urine strip / dipstick method for urine analysis.

Exercise: Quantitative determination of serum creatinine and urea.

Tests for cardiovascular diseases

Involvement of enzymes in diagnostics of heart disease including aspartate transaminase, isoenzymes of creatine kinase and lactate dehydrogenase and troponin.

Exercise: Assessment of hypertension by blood pressure measurement

Reference Books

- ▶ Medical Laboratory Technology - a Procedure Manual for Routine Diagnostic Tests Vol. I (2010), Mukherjee, K.L., Tata Mc Graw-Hill Publishing Company Limited (New Delhi). ISBN:9780070076594 / ISBN:9780070076631
- ▶ Medical Laboratory Technology - a Procedure Manual for Routine Diagnostic Tests Vol. II (2010), Mukherjee, K.L., Tata Mc Graw - Hill Publishing Company Ltd. (New Delhi), ISBN: 9780070076648.
- ▶ Medical Biochemistry (2005) 2nd ed., Baynes, J.W. And Dominiczak, M.H., Elsevier Mosby Ltd. (Philadelphia), ISBN: 0-7234-3341-0.
- ▶ Experimental Biochemistry: A Student Companion (2005) Rao, B.S. and Deshpande, V., IK International Pvt. Ltd. (New Delhi), ISBN:81-88237-41-8

5.4 SEC T4 - Bioinformatics and Biostatistics

Bioinformatics and Biostatistics	
	2 Credits
Introduction to bioinformatics	
Computer fundamentals - programming languages in bioinformatics, role of supercomputers in biology. Historical background. Scope of bioinformatics - genomics, proteomics, computer aided drug design (structure based and ligand based approaches). Applications of bioinformatics.	
Biological databases and data retrieval	
Introduction to biological databases - primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB). Exercises - Sequence retrieval (protein and gene) from NCBI. - Structure download (protein and DNA) from PDB.	
Sequence alignment	
Similarity, identity and homology. Alignment - local and global alignment, pairwise and multiple sequence alignments, alignment algorithms, amino acid substitution matrices (PAM and BLOSUM), BLAST analysis. Exercises BLAST suite of tools for pairwise alignment.	
Introduction to Biostatistics	
Variable and attribute; Population vs. sample; Census vs. sample survey; Arrangement of data; Frequency distribution.	
Graphical presentation of data	

Line diagram; Bar diagram; Pie chart; Histogram.

Measures of central tendency and Dispersion

Arithmetic mean; Mode; Median.

Variance; Standard deviation; Standard error of mean; Standard score.

Testing of hypothesis and goodness of fit

Null hypothesis, Level of significance, Probability, Normal distribution, Error of inference, Student's t-test, Paired t-test, Fisher's t-test, Chi-square test.

Reference Books

- ▶ Bioinformatics: Sequence and Genome Analysis (2001), 1st ed., Mount, D.W. Cold Spring Harbor Laborator Press (New York), ISBN: 0-87969-608-7.
- ▶ Bioinformatics and Functional Genomics (2003), 1st ed., Pevsner, J., John Wiley & Sons, Inc. (New Jersey), ISBN: 0-47121004-8.
- ▶ Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins (2005), 3rd ed., Baxevanis, A.D. and Ouellette, B.F., John Wiley & Sons, Inc. (New Jersey), ISBN: 0-47147878-4.
- ▶ Bioinformatics - Principles and Applications (2008), 1st ed. Ghosh, Z. and Mallick, B., Oxford University Press (India), ISBN: 9780195692303.

6. General Elective Subjects Syllabus

6.1 GE T1 - Biochemistry of Cell

Statistical Methods	
	4 Credits
Biomolecules in their cellular environment	
The cellular basis of life. Cellular structures - prokaryotes and eukaryotes. Chemical principles in biomolecular structure. Major classes of biomolecules. Role of water in design of biomolecules.	
Amino acids and peptides	
Types of amino acids and their chemistry, derivatives of amino acids and their biological role. Introduction to biologically important peptides.	
Sugars and polysaccharides	
Basic chemistry of sugars, optical activity. Disaccharides, trisaccharides and polysaccharides - their distribution and biological role.	
Nucleosides, nucleotides and nucleic acids	
Structures and chemistry, DNA structures and their importance, different types of RNA. Unusual DNA structures, other functions of nucleotides.	
Lipids	
Various classes of lipids and their distribution, storage lipids, structural lipids in membranes, lipids as signals, cofactors and pigments.	
Vitamins, coenzymes and metal ions	
Occurrence and nutritional role. Coenzymes and their role in metabolism. Metal ion containing biomolecules - heme, porphyrins and cyanocobalamin; their biological significance.	

Signalling molecules

Second messengers - cAMP, cGMP, IP₃, diacyl glycerol, Ca²⁺, NO. Brief account of their importance and role in signalling and signal transduction.

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13; 978-1-4641-0962-1 / ISBN: 10-14641-0962-1.
- ▶ Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN: 978-0-470-28173-4.

6.2 GE P1 - Biochemistry of Cell Lab

Biochemistry of Cell Lab	
	2 Credits
List of Practical	
1. General safety procedures in a laboratory. Calibration and Use of auto pipettes. 2. Making solutions and buffer preparation - acetate and tris buffers. 3. Qualitative tests for biomolecules - carbohydrates, lipids, amino acids, proteins, bases and nucleic acids. 4. Separation of amino acids by paper chromatography. 5. Estimation of ascorbic acid in fruit juices.	

6.3 GE T2 - Proteins and Enzymes

Proteins and Enzymes	
	4 Credits
Introduction to proteins	
Polypeptides and proteins. Subunit structures, conjugated proteins, diversity of function.	
Isolation and analysis of proteins	
Techniques to isolate and analyze proteins- salt fractionation, ion-exchange chromatography, gel permeation, HPLC, SDS-PAGE, and IEF. Protein primary structure - sequencing by Edman degradation, use of enzymes and chemical reagents to obtain overlap peptides. Synthesis of peptides using Merrifeld method.	
Introduction to protein three-dimensional structures	
Secondary structure- helices and sheets, Ramachandran maps. Nature of non-covalent bonds and covalent bonds in protein folding. Tertiary and quaternary structures.	
Myoglobin and haemoglobin - structure and function	
Oxygen binding curves, cooperativity models for haemoglobin.	
Introduction to enzyme catalysis	
Features of enzyme catalysis, superior catalytic power. General mechanisms of catalysis. Nomenclature.	
Enzyme kinetics	
Principles of reaction rates, order of reactions and equilibrium constants. Derivation of Michaelis-Menten equation. Significance of K_m and V_{max} . Catalytic efficiency parameters. Competitive and mixed inhibitions. Kinetics and diagnostic plots. Types of irreversible inhibitors.	
Mechanisms of enzyme action and regulation	
Mechanism of action of chymotrypsin. Inhibitors of enzymes - antibiotics. Allosteric Regulation	

of enzyme activity and its importance - aspartate transcarbamoylase

Enzymes in medicine and industry

Enzymes used in clinical biochemistry as reagents, diagnostics and therapy. Role of immobilized enzymes in industry.

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13: 978-1-4641-0962-1 / ISBN: 10-14641-0962-1.
- ▶ Fundamentals of Enzymology (1999) 3rd ed., Price, N.C and Stevens, L., Oxford University Press Inc., (New York), ISBN:13: 978-0-19-806439-8

6.4 GE P2 - Proteins and Enzymes Lab

Proteins and Enzymes Lab	
	2 Credits
List of Practical	
1. Protein estimation by UV absorbance and Biuret method. 2. Protein microassay by Lowry/Bradford method. 3. Ammonium sulphate fractionation of crude homogenate from germinated mung bean. 4. Setting up assay for alkaline phosphatase and activity measurements of the ammonium sulphate fractions (progress curve and effect of pH). 5. Determination of K_m and V_{max} of enzyme enriched fraction.	

6.5 GE T3 - Fundamentals of Cell Biology and Immunology

Fundamentals of Cell Biology and Immunology	
	4 Credits
Cells and organelles	
Prokaryotic and eukaryotic cells. Plasma membrane, the nucleus, intracellular membranes and organelles, mitochondria, chloroplast, endoplasmic reticulum, Golgi complex, lysosome, peroxisome, cytoskeleton, extracellular matrix, cell wall. Mitosis and meiosis.	
Membrane structure and function	
Composition of membranes, membranelipids, membrane proteins, isolation and characterization. Integral, peripheral and lipid anchored protein. Transport across membranes, simple and facilitated diffusion, active transport.	
Endoplasmic reticulum and Golgi complex	
The two types of endoplasmic reticulum, rough and smooth. The Golgi complex. Role of Golgi in protein glycosylation and protein trafficking.	
Signalling mechanisms, messengers and receptors	
Chemical signals and cellular receptors. G-protein linked receptors, protein kinase associated receptors. Hormonal signalling, cell signals and apoptosis.	
Cell cycle and its regulation	
Overview of the cell cycle. Regulation of the cell cycle, cyclin dependent kinases.	
Overview of the immune system	
Self-versus nonself. Humoral and cellular immunity. Innate and adaptive immunity. Cells of the immune system, primary and secondary lymphoid tissues and organs. Cellular and humoral responses.	
Innate immunity	

Defensins. Non-immunological barriers. Cells and soluble mediators of innate immunity. Acute phase proteins. Cytokines. Complement system.

Humoral B cell response

Structure of antibodies, types of immunoglobulins, generation of antibody diversity, B cell activation, theory of clonal selection, formation of plasma and memory cells; T-independent B-response; antigens, haptens carriers and adjuvants, antigen-antibody interaction

Cell mediated immunity

T-cell development, MHC locus. Structure, function and distribution of MHC glycoproteins. Antigen processing and presentation. Cell mediated immune responses by different T-cell sub populations. Hypersensitive reactions. Concept of autoimmunity.

Reference Books

- ▶ The World of the Cell (2009), 7th ed., Becker W.M., Kleinsmith, L.J., Hardin. J., Bertoni, and G.P., Pearson Benjamin Cummings (CA), ISBN: 978-0-321-55418-5.
- ▶ Prescott, Harley, Klein's Microbiology (2008) 7th Ed., Willey, J.M., Sherwood, L.M., Woolverton, C.J. Mc Graw Hill International Edition (New York) ISBN: 978-007-126727.
- ▶ Molecular Cell Biology (2013) 7th Ed., Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. and Scott, M.P., Macmillan International Edition (New York), ISBN: 13: 978-1-4641-0981-2.
- ▶ Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A., W.H Freeman and Company (New York), ISBN: 13: 978-0-7167-8590-3 / ISBN: 10:0-7617-8590-0.
- ▶ Immunology: A Short Course (2009) 6th ed., Coico, R and Sunshine, G., John Wiley& Sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.

6.6 GE P3 - Fundamentals of Cell Biology and Immunology Lab

Fundamentals of Cell Biology and Immunology Lab	
	2 Credits
List of Practical	
1. Visualization of animal and plant cell by methylene blue. 2. Identification of different stages of mitosis in onion root tip. 3. Isolation of organelles by sub-cellular fractionation. 4. Blood Grouping 5. Antigen-antibody interaction by Ouchterlony double diffusion.	

6.7 GE T4 - Fundamentals of Genetic Engineering

Fundamentals of Genetic Engineering	
	4 Credits
Introduction to recombinant DNA technology	
Overview of recombinant DNA technology. Plasmids and bacteriophage DNA as cloning vectors, pBR322, pUC8. Purification of plasmid and bacteriophage DNA. Enzymes used in manipulating DNA, separation by electrophoresis.	
Cloning vectors for prokaryotes and eukaryotes	
Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors based on E. coli plasmids, pBR322, pUC8, pGEM3Z. Cloning vectors based on M13 and λ bacteriophage.	
Construction, selection and identification of recombinants	
Ligation of DNA molecules. Transformation and electroporation, selection for transformed cells. Identification for recombinants, blue-white selection. Identification of recombinant phages. Direct selection, marker rescue. Gene libraries. Identification of a clone from gene library, colony and plaque hybridization probing, methods based on detection of the translation product of the cloned gene.	
Polymerase chain reaction and DNA sequencing	
Fundamentals of polymerase chain reaction, designing primers for PCR. Analysis of PCR products. DNA sequencing by Sanger's method and automated DNA sequencing.	
Expression of cloned genes	
Vectors for expression of foreign genes in E. coli, cassettes and gene fusions. Challenges in producing recombinant protein in E. coli. Production of recombinant protein by eukaryotic cells. Fusion tags and their role in purification of recombinant proteins.	
Applications of genetic engineering in biotechnology	

Expression of cloned genes. Vectors for expression of foreign genes in E coli, cassettes and gene fusions. Production of recombinant pharmaceuticals such as insulin. Gene therapy. Genetically modified plants such as herbicide resistant crops with special reference to BT cotton

Reference Books

- ▶ Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York), ISBN:0-321-50781 / ISBN: 978-0-321-50781-5.
- ▶ Gene Cloning and DNA Analysis (2010) 6th ed., Brown, T.A., Wiley-Blackwell Publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
- ▶ Principles of Gene Manipulation and Genomics (2006) 7th ed., Primrose, S. B., and Twyman, R. M., Blackwell publishing (Oxford) ISBN: 13: 978-1-4051-3544-3.
- ▶ Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) 4th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC), ISBN: 978-1-55581-498-4 (HC).
- ▶ Recombinant DNA: Genes and Genomes 3rd edition (2007): Watson, James D., et all. W.H. Freeman ISBN-10: 1429203129/ISBN-13: 978-1429203128

6.8 GE P4 - Fundamentals of Genetic Engineering Lab

Fundamentals of Genetic Engineering Lab	
	2 Credits
List of Practical	
1. Ultraviolet absorption spectrum of DNA and RNA. 2. Isolation of plasmid DNA and restriction digestion. 3. Agarose Gel electrophoresis 4. Amplification of a DNA fragment by PCR and gel electrophoresis 5. Determination of transformation efficiency.	

6.9 GE T5 - Intermediary Metabolism and Diseases

Intermediary Metabolism and Diseases	
	4 Credits
Basic concepts and design of metabolism	
The nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency	
Glucose and glycogen metabolism	
Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis. Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis.	
Citric acid cycle and oxidative phosphorylation	
Pyruvate dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway. The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3-phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.	
Amino acid and Nucleotide metabolism	
Protein degradation to amino acids, urea cycle, feeder pathways into TCA cycle. Nucleotide Biosynthesis - de novo and salvage pathways, regulation of nucleotide synthesis by feedback inhibition, degradation and excretion.	
Inborn errors of metabolism	
Alkaptonuria, Phenylketonuria, Glycogen and Lipid storage diseases, SCID, Clotting disorders.	
Hormonal Imbalances	

Outline of hormone action and imbalances leading to disease - precocious puberty, hyper and hypopituitarism. Hyper and hypothyroidism.

Diseases caused due to misfolded proteins

Alzheimer's, Huntington's disease, Kuru, Creutzfeldt-Jakob disease, Sickle cell anaemia, Thalassemia.

Reference Books

- ▶ Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN: 13: 978-1-4641-0962-1 / ISBN: 10-14641-0962-1.
- ▶ Harpers Illustrated Biochemistry (2015) 30th edition, Rodwell Victor W, Bender David A., Botham Kathleen M., Kennely Peter J., and Weil P. Anthony, Mcgraw Hill Education, ISBN-13: 978-0071825344/ ISBN-10: 0071825347
- ▶ Biochemistry (2012) 7th ed., Berg, J.M., Tymoczko, J.L. and Stryer, L., W.H Freeman and Company (New York), ISBN: 13:978-1-4292-7635-1.
- ▶ Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
- ▶ Genetics (2012) 6th ed., Snustad, D.P. And Simmons, M.J., John Wiley & Sons.(Singapore), ISBN: 978-1-118-09242-2.

6.10 GE P5 - Intermediary Metabolism and Diseases

Intermediary Metabolism and Diseases	
	2 Credits
List of Practical	
1. Estimation of blood glucose. 2. Assay of serum transaminases - SGOT and SGPT. 3. Estimation of serum urea, uric acid and creatinine. 4. Lipid profile: triglycerides and total cholesterol. 5. Leukocyte counting and haemoglobin estimation.	

7. Appendix I - Scheme for CBCS Curriculum for Pass Course

7.1 Credit Distribution across Courses

Credits				
Course Type		Total Papers	Theory + Practical	Theory*+Tutorials
Core Courses	4 papers each from 3 disciplines of choice	12	12*4 =48	12*5 =60
			12*2 =24	12*1=12
Elective Courses	2 papers each from 3 discipline of choice including interdisciplinary papers	6	6*4=24	6*5=30
			6*2=12	6*1=6
Ability Enhancement Language Courses		2	2*2=4	2*2=4
Skill Enhancement Courses		4	4*2=8	4*2=8
Totals		24	120	120

*Tutorials of 1 Credit will be conducted in case there is no practical component

- All Pass courses will have 3 subjects/disciplines of interest. Student will select 4 core courses each from discipline of choice including Biochemistry as one of the disciplines. The details for core courses available in Biochemistry have been detailed in Section 3 of this document
- Student will select 2 core courses each from discipline of choice including Biochemistry as one of the disciplines. The details for elective courses available in Biochemistry have been detailed in Section 4 and 6 of this document
- Student may also chose Skill Enhancement courses in Biochemistry. The details for skill enhancement courses available in Biochemistry have been detailed in Section 5 of this document

7.2 Scheme for CBCS Curriculum

Semester	Course Name	Course Detail	Credits
I	Ability Enhancement Compulsory Course-I	English communication / Environmental Science	2
	Core course-I	Core Course 1A from Biochemistry	4
	Core course-I Practical	Core Course 1A Practical from Biochemistry	2
	Core course-II	Core Course 2A from other chosen discipline	4
	Core course-II Practical	Core Course 2A Practical from other chosen discipline	2
	Core course - III	Core Course 3A from other chosen discipline	4
	Core course - III Practical	Core Course 3A Practical from other chosen discipline	2
II	Ability Enhancement Compulsory Course-II	English communication / Environmental Science	2
	Core course-IV	Core Course 1B from Biochemistry	4
	Core course-IV Practical	Core Course 1B Practical from Biochemistry	2
	Core course-V	Core Course 2B from other chosen discipline	4
	Core course- V Practical	Core Course 2B Practical from other chosen discipline	2
	Core course - VI	Core Course 3B from other chosen discipline	4
	Core course - VI Practical	Core Course 3B Practical from other chosen discipline	2
III	Core course VII	Core Course 1C from Biochemistry	4
	Core course-VII Practical	Core Course 1C Practical from Biochemistry	2
	Core course - VIII	Core Course 2C from other chosen discipline	4
	Core course - VIII Practical	Core Course 2C Practical from other chosen discipline	2
	Core course-IX	Core Course 3C from other chosen discipline	4
	Core course-IX Practical	Core Course 3C Practical from other chosen discipline	2
	Skill Enhancement Course-1	TBD	2

IV	Core course-X	Core Course 1D from Biochemistry	4
	Core course - X Practical	Core Course 1D Practical from Biochemistry	2
	Core course-XI	Core Course 2D from other chosen discipline	4
	Core course-XI Practical	Core Course 2D Practical from other chosen discipline	2
	Core course-XII	Core Course 3D from other chosen discipline	4
	Core course-XII Practical	Core Course 3D Practical from other chosen discipline	2
	Skill Enhancement Course-2	TBD	2
V	Skill Enhancement Course - 3	TBD	2
	Discipline Specific Elective 1	DSE 1A from Biochemistry	4
	Discipline Specific Elective 1 Practical	DSE 1A Practical from Biochemistry	2
	Discipline Specific Elective 2	DSE 2A from other chosen discipline	4
	Discipline Specific Elective 2 Practical	DSE 2A Practical from other chosen discipline	2
	Discipline Specific Elective 3	DSE 3A from other chosen discipline	4
	Discipline Specific Elective 3 Practical	DSE 3A Practical from other chosen discipline	2
VI	Skill Enhancement Course - 4	TBD	2
	Discipline Specific Elective 4	DSE 1B from Biochemistry	4
	Discipline Specific Elective 4 Practical	DSE 1B Practical from Biochemistry	2
	Discipline Specific Elective 5	DSE 2B from other chosen discipline	4
	Discipline Specific Elective 5 Practical	DSE 2B Practical from other chosen discipline	2
	Discipline Specific Elective 6	DSE 3B from other chosen discipline	4
	Discipline Specific Elective 6 Practical	DSE 3B Practical from other chosen discipline	2