UNIVERSITY OF CALCUTTA

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Dated the 05th December, 2017

To
The Principals/T.I.C.
of all the Undergraduate Colleges
offering B.Sc. (Honours and General) in Bio-Chemistry
affiliated to the University of Calcutta

Sir/Madam,

The undersigned is to inform you that the proposed **revised semesterised draft Syllabus for Bio-Chemistry (Honours and General)** Courses of Studies under **CBCS has been uploaded in the Calcutta University website (www.caluniv.ac.in).**

The said syllabus has been prepared by the **U.G. Board of Studies in Bio-Chemistry, C.U.**, suppose to be implemented from the academic session 2018-2019

You are requested kindly to go through it and send your feedback within 31st December, 2017.

In this regard you may send your observation/ suggestion to the **Department of U.G. Councils, C.U.** or through email (u.g.councilsc.u@gmail.com), and you also may contact **Prof. Anirban Siddhanta,** Department of Bio-Chemistry through e-mail **(asiddhanto@yahoo.com).**

Your cooperation in this regard will be highly appreciated. Kindly treat the matter as urgent.

Thanking you,

Yours faithfully,

05.12.17

(Milan Kr. Pal)
O.S.D., C.U.

Dr. Milan Kumar Pal
O.S.D.
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UNIVERSITY OF CALCUTTA

SYLLABUS

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THREE-YEAR B.SC.

CBCS COURSE OF STUDIES

BIOCHEMISTRY

2018

1. Scheme for CBCS Curriculum

1.1 Credit Distribution across Courses

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

Credit distribution assuming that all four GE courses a student has chosen have practical components.

Sem	Core	Electives			Ability Enhancement	Total Credits
		General	Skill	Discipline		
I	6X2=12	6	-		2	20
II	6X3=18	6	-		2	26
III	6X2=12	6	2		-	20
IV	6X3=18	6	2		-	26
V	6X2=12	-	-	6X2=12	-	24
VI	6X2=12	-	-	6X2=12	-	24
Total Credits	84	24	4	24	4	140

1.1 Scheme for CBCS Curriculum

Semester	Course Name	Course Detail	Credits
I	Ability Enhancement Compulsory Course–I	Bengali/English communication / Environmental Science/	2
	Core course–I	Molecules of Life I	4
	Core course–I Practical	Molecules of Life I	2
	Core course–II	Molecules of Life II	4
	Core course–II Practical	Molecules of Life II	2
	Generic Elective–1	Organic chemistry (Section-A): General chemistry Physical chemistry (Section-B): General Physical chemistry	4
	Generic Elective–1Practical	Organic chemistry practical	2
II	Ability Enhancement Compulsory Course–II	Bengali/English communication/Environmental Science/	2
	Core course–III	Bio-Physical chemistry	4
	Core course–III Practical	Bio- Physical chemistry practical	2
	Core course–IV	Enzymes	4
	Core course–IV Practical	Enzymes	2
	Generic Elective–2	Organic Chemistry (Section-A): General reaction mechanisms Physical Chemistry (Section-B): Thermodynamics,	4

		Chemical equilibrium	
	Generic Elective–2 Practical	**Physical chemistry practical**	**2**
	Core course–V	**Metabolism of Carbohydrates and Lipids**	**4**
	Core course–V Practical	**Metabolism of Carbohydrates and Lipids**	**2**
III			
	Core course–VI	**Physiology and Hormones**	**4**
	Core course – VI Practical	**Physiology and Hormones**	**2**
	Core course–VII	**Cell Biology**	**4**
	Core course–VII Practical	**Cell biology**	**2**
	Skill Enhancement Course–1	**Tools & techniques in Biochemistry**	**2**
	Generic Elective–3	**Zoology/ UGC Syllabus in Life sciences: Core course-Zoology-3 (Physiology & Biochemistry)**	**4**
	Generic Elective–3Practical	**Zoology/ UGC Syllabus in Life sciences: Core course-Zoology-3 (Physiology & Biochemistry)**	**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	**Clinical Biochemistry**	**2**

	Generic Elective–4	**Zoology/ UGC Syllabus in Life sciences: Core course-Zoology-4 (Genetics)**	**4**
	Generic Elective–4Practical	**Zoology/ UGC Syllabus in Life sciences: Core course-Zoology-4 (Genetics)**	**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– 1Practical	**Nutritional Biochemistry**	**2**
	Discipline Specific Elective–2	**Molecular basis of infectious & non-infectious human diseases**	**4**
	Discipline Specific Elective– 2Practical	**Molecular basis of infectious & non-infectious human diseases**	**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– 3Practical	Advanced Biochemistry	2
	Discipline Specific Elective–4	Molecular diagnostics	4
	Discipline Specific Elective– 4 Practical	Molecular diagnostics	2

1.2 Choices for Discipline Specific Electives

Discipline Specific Elective – 2	Discipline Specific Elective – 2
Molecular basis of infectious and non-infectious human diseases	Molecular Diagnostics

1.3 Choices for Skill Enhancement Courses

Skill Enhancement Course-1&Skill Enhancement Course-2		
Techniques in Biochemistry	Clinical Biochemistry	

Core Subjects Syllabus

Core T1 – Molecules of Life I

Molecules of Life I	
	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). (definition, structure, functions, examples only) Carbohydrates as informational molecules, working with carbohydrates (applications of carbohydrate)	
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 (preliminary ideas only)	
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 (examples & functions only)**
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- provide necessary details on latest edition** **Edited by Prof. Hiren K Das (JNU)**

Core P1 – Molecules of Life I Lab

Molecules of Life	
	2 Credits
List of Practical	
1. **Safety measures in laboratories, use and calibration of pipettes** 2. **Preparation of normal, molar and percent solutions** 3. **Concept of pH and preparation of buffers.** 4. **Separation of amino acids by thin layer chromatography.** 5. **Qualitative test for carbohydrate, lipid & amino acids**	

Core T2 – Molecules of life II

Proteins	
	4 Credits
Introduction to amino acids, peptides and proteins	

Amino acids:

Definition, classification & structures. Physico-chemical properties of amino acids(amphoteric molecules, ionisation, zwitterions, pk values, isoelectric point, Lambert-Beer's law, optical density, absorption spectra), titration of amino acids (glycine, glutamic acid, lysine, histidine), Formol titration of glycine (only reaction and principle), reaction of amino acids: reaction due to amino groups(reaction with mineral acids,alkyl halides, acetyl chloride, acetic anhydride in presence of base, nitrous acid, ninhydrin and fluorescamine), reaction due to carboxylic acid group (reaction with base, alcohol, $LiAlH_4$, metal oxide), separation and analysis of amino acids by paper & thin layer chromatography and HPLC.

Peptides & Proteins:
Peptide bond: Definition, structure and geometry of peptide bond, example of biologically important peptide and its functions in brief (glutathione-peptide of non protein origin), Merrifield solid-phase peptide synthesis using protection/ deprotection protocol (brief outline). N-terminal amino acid determination (Edman degradation, dansyl chloride reagent, Sanger's reagent) and C-terminal amino acid determination (carboxypeptidase and using hydrazine).
Proteins : Definition & structure, primary, secondary, tertiary and quaternary structure (definition and example), structure of globular protein (albumin, globulin, haemoglobin & myoglobin – Structure, function and occurrence in brief) and fibrous protein (keratin, collagen -role of Vitamin C in hydroxylation, elastin- Structure, function and occurrence in brief), Forces that stabilise structure of proteins, behaviour of proteins in solutions, salting in and salting out, Denaturation and renaturation of proteins (example - RNase), absorbance of proteins, example of metalloprotein, lipoprotein. Biuret and Folin-Lowry test for protein.

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. (brief outline) **Ammonium sulphate fractionation, solvent fractionation, dialysis and lyophilisation.** **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 chromatography, molecular sieve chromatography, hydrophobic interaction/reverse phase chromatography, affinity chromatography and FPLC (brief concept)** **Determination of purity, molecular weight, extinction coefficient and sedimentation coefficient, IEF, SDS-PAGE and 2-D electrophoresis.**
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.
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**

Core P2 – Molecules of life II Lab

Proteins	
	2 Credits
List of Practical	
1. **Qualitative tests for proteins** 2. **Estimation of proteins using UV absorbance and Biuret method.** 3. **Assay of proteins using Lowry method, standard curve preparation** 4. **SDS-PAGE analysis of proteins (BSA, Lysozyme, Ovalbumin)** 5. **Ammonium sulphate fractionation of serum proteins.**	

Generic Elective-1

Section A: General organic chemistry

Unit-I

1. Atomic Structure

Extra nuclear structure: Bohr's theory of atomic structure and its limitations, Summerfeld's modification, application of Bohr's theory to hydrogen like atoms and ions, Spectrum of hydrogen atom. Quantum numbers, Preliminary idea of de Broglie matter waves, concept of atomic orbital, shapes of s, p and d orbitals, radial and angular probability of s, p and d orbitals (qualitative idea). Many electron atoms, Pauli Exclusion Principle, Hund's rule of maximum multiplicity, exchange energy, Aufbau (building up) principle and its limitations, Electronic energy levels and electronic configurations of hydrogen like and polyelectronic atoms and ions (concept only), Ground state term symbols of atoms and ions (concept only).

2. Intermolecular forces

a. Ionic bonding

Size effects- radius ratio rules and their limitations. Packing of ions in crystals, Lattice energy (concept only), Born-Lande equation (derivation not required) and its applications; Born-Haber cycle (derivation not required) and its application. Preliminary ideas of solvent energy, polarizing power and polarisibility, ionic potential and Fajan's rules.

b. Covalent bonding

Lewis structures, formal charge, Preliminary idea of Valence Shell Electron Pair Repulsion (VSEPR) Theory, shapes of molecules and ions containing lone pairs and bond pairs. Partial ionic character of covalent bonds, bond moment and dipole moment, Partial ionic character from dipole moment values and electro negativity differences, Preliminary idea of valence Bond Theory (Heitler- London approach). Directional character of covalent bonds, hybridization, equivalent and non equivalent hybrid orbital, Bent's rule; Concept of resonance, resonance energy, resonance structures.bonding, non-bonding,antibonding molecular orbitals(concept only) elementary pictorial approach of H_2 and O_2 molecular orbitals , sigma and pi bonds, multiple bonding. Concept of Bond order, bond length, bond strength, bond energy

c. Weak Chemical Forces

Van der Waal's forces, ion-dipole, dipole–dipole interactions, London forces, Hydrogen bonding; Effect of chemical forces on physical properties

d. Co-ordination compounds

Double salts and complex salts, Werner's theory, ambidentate and polydentate

ligands, chelate complexes, Naming of co-ordination compounds (up to two metal centres). Isomerism of co-ordination compounds: Constitutional, geometrical and optical isomerism in respect co-ordination numbers 4 and 6. Determination of configuration of cis-, trans-, isomers by chemical methods.

Unit-II:

Bonding and Stereochemistry of Carbon Compounds

Concept of hybridisation, resonance (including hyperconjugation), inductive effect Huckel's rules for aromaticity & antiaromaticity. dipole moment, bond distance, bond angles Tautomerism: keto-enol tautomerism

Ionization of acids and bases: effect of structure, substituent and solvent on acidity and basicity (Simple Aliphatic and aromatic Acids, Phenols and amines).

Stereochemistry Optical activity of chiral compounds: specific rotation, measurement of specific rotation by polarimeter, racemisation (general principle) resolution of simple acids and bases.

Representation of molecules in saw horse, Fischer, flying-wedge and Newman formulae and their inter translations, Configuration: stereocentres: systems involving 1, 2, 3 centres, stereogenicity, chirotopicity. pseudoasymmetric (D/L and R/S descriptor threo/erythro and syn/anti nomenclatures ii) stereoaxis in C=C & C=N systems, cis/trans, syn/anti, E/Z descriptors.

Coformation: Conformational nomenclature, eclipse, staggard, gauch and anti forms ; dihedral angel, torsion angel, energy barrier of rotation; Conformational analysis of
ethane, propane and n-butane;Conformational analysis of cyclohexane(chair and boat forms), symmetry properties, optical activity and relative stabilities of cyclohexane systems;

.

Unit III:

General treatment of reaction mechanisms

Ionic and radical reactions; heterolytic and, homolytic bond cleavage

***Reactive intermediates*: carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes – structure using orbital picture, electrophilic/nucleophilic behaviour, stability, generation and fate. Reaction kinetics: transition state theory,rate constant and free energy of activation, free energy profiles for one step and two step reactions.**

Nucleophilic substitution reactions- S_N1, S_N2, S_N^i mechanisms. Effect of substrate structure, nucleophiles and medium on reactivity and mechanism; neighboring group participations.

Elimination Reactions- E1, E2, and E1cB mechanisms. Saytzeff and Hofmann rules. Elimination vs substitution reaction.

Electrophilic and Activated Nucleophilic substitution reactions of Benzene (Nitration, sulphonation, Halogenation and Friedel Craft reactions)

Reference Books

1. **General &Inorganic Chemistry-R.P.Sarkar**
2. **Inorganic Chemistry-R.L.Dutta**
3. **New Concise Inorganic Chemistry-J.D.Lee**

Section B: General physical chemistry

Unit-I:

Biophysical properties

(a) **Viscosity:** General features of fluid flow (streamlined and turbulent), nature of viscous drag for streamlined motion. Definition of viscosity coefficient. Origin of viscosity of liquids, expression for viscosity coefficient of liquids (with derivation): Poiseuille's equation, temperature dependence of viscosity coefficient of liquids. Stoke's law and terminal velocity. Determination of viscosity coefficient of liquids. Diffusion of solutes in solution, Fick's law.

(b) **Surface tension:** Definition, angle of contact, interfacial tension, capillary rise, determination of surface tension, temperature effect.

(c) **Preliminary idea of Chemical equilibrium:** Equilibrium constant, Le Chatelier's principle and its simple applications.

Ionic equilibrium: Standard solution, Molar, Normal, Molal, Formal and percent strengths, Hydrolysis of weak acids and bases. pK_a, pK_b, pH, pOH acid- base neutralization curves, Buffer action definition, Henderson -Hasselbalch equation and preparation of buffers, buffer capacity, Solubility product principle and application.

Unit-II:

Electrochemistry:

Flow of electrical charge: Electrical conductance, cell constant, specific conductance and equivalent conductance. Variation of equivalent conductances of strong and weak electrolytes with dilution, Kohlrausch's law of independent migration of ions, ion conductances and ionic mobility, Equivalent conductances at infinite dilution for weak electrolytes and determination of dissociation constants of weak electrolytes from conductance measurements. Basic concepts of electrochemical cell and cell reactions. EMF of cell (no derivation), types of electrode, glass electrode, determination of pH of a solution and potentiometric titration, redox reaction.

Unit-III:

Chemical Kinetics:

(a) Concepts of rate, rate constant, order and molecularity of a reaction, integrated form of rate expressions; half-life period and its significance.

(b) Pseudo-unimolecular reactions, multi step reactions, rate determining step, zero and fractional orders, rate expressions for complex reactions, Steady-State approximation. Opposing reaction, parallel reaction and consecutive reaction. Temperature dependence of rate constant, Arrhenius'equation, Energy of Activation; Concept of Collision theory and Transition State theory of reaction rate.

(c) Catalytic reactions: Homogeneous catalysis, acid –base catalysis, primary salt effects, Autocatalysis, Adsorption of gases on solids, Langmuir adsorption isotherm, Heterogeneous catalysis, examples.

Reference Books

1. **Physical Chemistry-P.C.Rakshit**
2. **Lehninger Principles of Biochemistry-Nelson & Cox**
3. **Text Book of Physical Chemistry-K.L.Kapoor (Vol-II,V)**
4. **Physical Chemistry-Hrishikesh Chatterjee (Vol-I**

Generic Elective–1Practical: Organic chemistry practical

1. **Physical characteristics (colour, odour, texture)**

2. **Preliminary Tests:**
   (Ignition Test, litmus Test, Beilstein test for halogen, Br_2 in AcOH/water or $KMnO_4$ in water test)
3. **Detection of special elements (N, Cl, S) by Lassaigne's tests.**
4. **Solubility and classification**
   (Solvents: H_2O, 5% HCl, 5% $NaHCO_3$, 5% NaOH)
5. **Detection of the following functional groups by systematic chemical tests: (aromatic amino ($–NH_2$), Amido ($–CONH_2$, including imide), aromatic nitro ($– NO_2$), Phenolic –OH, Carboxylic acid (–COOH), Carbonyl (>C= O); only one test for each functional group is to be reported)**

*Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups in known and unknown organic compounds. Each student, during laboratory session, is required to analyze at least SIX (6) unknown organic samples. In practical examination, one unknown solid organic compound containing not more than two of the above functional groups (IV) shall be assigned to a candidate through a single draw lottery.

B. **LABORATORY RECORDS**

7. Candidates at the practical examinations are required to submit the day to day record of all types of laboratory works prescribed in the syllabus performed by them and duly signed by their teachers. Marks of the laboratory records shall be awarded by the examiner at the practical examination. Candidates failing to submit their laboratory note books may be debarred from the examination.

Practical Reference Books

(i) Advanced Practical Chemistry – Subhas Ch. Das
(ii) Handbook of Practical Chemistry – University of Calcutta

Core T3 –Bio-Physical chemistry

Bio-Physical chemistry	
	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	
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. **Techniques used in studying 3-D structures - X-ray diffraction and NMR (introductory) Motifs and domains. (bonding concept of protein, DNA)**	
Spectroscopy-II	
Spectroscopic techniques using plane polarized light: polarized light, chirality of biomolecules, circular dichroism and linear dichroism. Determination of 2D structures. **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. Dihedral angles psi and phi. Helices, sheets and turns. Ramachandran map.**	
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
▸ **Physical Biochemistry, Principles and Applications, David Sheehan** ▸ **Physical Biochemistry, David Friefelder- provide necessary details** ▸ **Biophysical Chemistry (Principles and Techniques); Upadhyay and Upadhyay- provide necessary details** ▸ **Physical Biochemistry, Van Holde- provide necessary details**

Core P3 – Physical Biochemistry Lab

Physical Biochemistry	
	2 Credits
List of Practical	
1. **Preparation of buffers and pH determination** 2. **Determination of extinction coefficient of different BSA solutions by spectrophotometer.** 3. **Column chromatography (size exclusion) by teaching kit. (Determination of Void volume)**	

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. Km and Vmax, Kcat 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, Malcolm Dixon, Edwin Clifford Webb- provide necessary details**
- **Biochemical Calculations, Segel- provide necessary details**

Core P4 – Enzymes Lab

Enzymes	
	2 Credits
List of Practical	
1. **Assay of enzyme activity and specific activity of Alkanine Phosphatases.** 2. **Effect of pH on the enzyme activity** 3. **Determination of Km and Vmax using Lineweaver-Burk graph.** 4. **Enzyme inhibition - calculation of Ki for competitive inhibition.**	

Generic Elective-2
Section A: General reaction mechanisms

Unit-I:

Specific Reactions and Heterocycles

Addition reactions to Carbon–carbon multiple bonds- Electrophilic additions- mechanisms of halogenations, hydrohalogenation, hydration, hydroboration, epoxidation, hydroxylation, ozonolysis.

Nucleophilic addition to carbonyl groups: relative reactivity of carbonyl compounds. Formation of acetal, $LiAlH_4$ and $NaBH_4$ reductions, Grignard reactions, Cannizzaro, aldol condensation.

Heterocycles- Structural aspects of five and six membered heterocycles containing hetero atoms (furan, pyran, pyridine, pyrrole, furanose, pyranose, purines, pyrimidines). Aromaticity of heterocyclic compounds; basicity of pyridine and pyrrole. Tautomerism in heterocyclic systems.

Unit-II:

Radioactivity

Laws of radioactivity, Radioactive decay,decay constant, average life of radio elements and its relation with half life,radioactive equilibrium,properties of α,β,γ radiations,radiation damage, radiation protection and safety aspects, units of radioactivity,radioactive carbon dating,

Atomic Nucleus

Fundamental particles of atomic nucleus, atomic number and its significance, nucleus stability,neutron proton ratio and different modes of decay, nuclear biding energy, nuclear forces.

Applications of radioactive isotopes

Examples of radio isotopes (^{14}C, ^{3}H, ^{32}P, ^{35}S, ^{2}H) and their uses in biological systems. Basic principles of liquid scintillation counter. Radiation absorption, Radiation therapy in cancer (examples only)

Reference Books

1.Organic Chemistry (vol.1&2) – I.L.Finar
2.A Guide to Organic Reaction Mechanism- P. Sykes
3.Stereochemistry of Carbon Compounds- D. Nasipuri
4.Basic Stereochemistry of Organic Compounds- S. Sengupta

Physical Chemistry (Section-B): Thermodynamics, Chemical equilibrium & Solutions

Unit-I:

1. **Principles of thermodynamics**
   - **(a) Definition of systems, surroundings and types of systems (isolated, closed and open). Extensive properties and intensive properties, concept of Thermodynamic equilibrium, concept of temperature, concept of heat and work, reversible work, irreversible work and maximum work.**
   - **(b) First law of Thermodynamics, internal energy as a state function, properties of a state function, definition of isothermal and adiabatic processes, Joule's experiment and its consequences. Joule-Thomson experiment and enthalpy as a state function, calculation of work done, heat changes for isothermal and adiabatic changes involving ideal gas.**

(c) **Statement of Second law of Thermodynamics and their equivalence, Carnot's cycle and Carnot's theorem, Absolute scale of temperature, concept of Entropy as a state function, Entropy changes in various Physical processes.**

(d) **Clausius inequality, condition of reversibility and irreversibility of a process, auxiliary state function-Helmholtz free energy and Gibbs free energy and their simple applications.**

(e) **Laws of Thermo chemistry and their applications, Born Haber Cycle, Standard Enthalpy changes in various transformations, Kirchoff's relation.**

(f) **Maxwell's relation, C_p-C_v relation, Joule- Thompson coefficient for Van der Waal gases, Thermodynamic Equation of state. (brief introduction)**

(g) **Gibbs- Helmholtz relation, Coupling reactions, concept of orders of phase transition, Clausius- Clapeyron relation and phase transition. (brief introduction)**

Unit-II:

Chemical Equilibrium: State of equilibrium and thermodynamic condition of equilibrium (condition of Minimum Gibbs' potential), Van't Hoff's reaction isotherm (deduction using chemical potential), Temperature dependence of Equilibrium constant (brief introduction).

(i) **Homogeneous equilibrium : Use of different standard states to define K_p, K_c, K_x and their interrelations, examples of homogenous equilibrium in gas phase and ionic equilibrium in solution.**

(ii) **Heterogeneous equilibrium: Chemical equilibrium in different phases, Distribution/ partition constant.**

Colloidal State: Electrokinetic phenomena- concept of Zeta potential, stability of colloids, mechanism of coagulation, Brownian motion, Electrical property of membrane, Donann membrane equilibrium. Gibbs adsorption isotherm-statement and significance, Surfactant, Micelle formation.

Ideal and non- ideal Solutions and Thermodynamics of EMF of Cells

Ideal solutions: Raoult's law of relative lowering of vapour pressure (brief introduction). Thermodynamic derivation of colligative properties of solution (using chemical potential) and their inter relationships.

Non-ideal solutions: Concept of activity and activity coefficient with special reference to electrolyte solutions, statement of Debye-Huckel limiting law and its applications. Thermodynamic derivation of EMF, its use in measuring thermodynamic properties. (brief introduction)

Reference Books

1. Physical Chemistry-P.C.Rakshit
2. Text Book of Physical Chemistry-K. L. Kapoor (Vol-II,III,V)
3. Physical Chemistry-Hrishikesh Chatterjee(Vol-I,II)
4. Lehninger Principles of Biochemistry-Nelson &Cox
5. Molecular Spectroscopy-C. N. Banwell& McCash

6. Organic Spectroscopy-William Kemp
7. Techniques and Methods in Biology-K. L. Ghatak

Generic Elective-2 Practical: Physical chemistry practical

1. Potentiometric titration (Mohr vs. dichromate).
2. Determination of solubility and solubility product of a sparingly soluble salt by titrimetric method.
3. Determination of specific rotation of a given optically active compound and %composition of its aqueous solution using Polarimeter.
4. Determination of viscosity coefficient of a given liquid/solution with Ostwald viscometer.
5. To study the kinetics of saponification of ester by conductometric method.

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.
Eicosanoids, cholesterol, steroids and isoprenoids
Precursor, regulation, functions and physiological importance of prostagladins, leukotrienes and thromboxanes. Precursor, regulation, functions and physiological importance of Cholesterol, steroids and isoprenoids.
Membrane lipids
Precursor, regulation, functions and physiological importance of of membrane phospholipids in prokaryotes and eukaryotes, respiratory distress syndrome, Precursor, regulation, functions and physiological importance of triacylglycerol, plasmalogens, sphingolipids and glycolipids, lipid storage diseases.
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**
- **Biochemistry Book edited by Hiren Das**

List of Practical
1. Assay of amylase by Kit method. 2. Estimation of cholesterol from known source (Mustard oil) 3. Isolation of serum LDH by kit method. 4. Estimation of pure glucose by Nelson-Somogyi method.

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	
Relationship between cardiac cycle, control of cardiac function and output. 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. HORMONE: Endocrine systems: Pituitary hormones functions and targets (tabular form) Digestive mechanism	

Structure and functional organization, Biochemical mechanisms of carbohydrate, lipid, Protein or nucleic acid digestion, absorption **Excretory mechanism** **Kidney: functional organization, GFR, selective re-absorption & secretion, buffering system, Acid base balance, acidosis and alkalosis, biochemical principles of water and electrolyte imbalance, polyuric states, nephrogenic Diabetes insipidus (antidiuretic hormone-vasopressin).**
Thyroid hormone
Name and biochemical actions of thyroid hormones and its regulations. Iodine requirement and deficiency of thyroid hormones.
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 - adenyl cyclase, guanyl cyclase, PDE, PLC.
Hypothalamic and pituitary hormones
Hypothalamic - 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, adipolectin, leptin and ghrelin. Summary of hormone metabolite control of GI function. Physiological and biochemical action.
Hormones of adrenals
Aldosterone, renin angiotensin system, cortisol, epinephrine and norepinephrine. (physiological and biochemical actions and their deficiencies) Fight or flight response, stress response.
Reference Books

- **Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M. W.H. Freeman & Company (New York), ISBN: 13: 978-1-4641-0962-1 / 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 (New Delhi), Inc. ISBN: 978-81-317-2610-5.**
- **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.**
- **Human Physiology by C. C. Chatterjee-provide necessary details**
- **Biochemistry by Debajyoti Das-provide necessary details**
- **Medical Physiology by Guyton and Hall-provide necessary details**

Core P6 – Physiology and Hormones Lab

Physiology and Hormones	
	2 Credits
List of Practical	
1. **Estimation of haemoglobin.** 2. **Separation of plasma proteins by SDS-PAGE.** 3. **Separation of isoenzymes of LDH by electrophoresis (SDS-PAGE).** 4. **Estimation of serum Ca2+.** 5. **Estimation of serum cholesterol by PAP method.**	

Core T7 –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, fluorescencemicroscopy, confocal microscopy, electron microscopy, Centrifugation for subcellular fractionation.	
Structure and functions 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 and tubulin filaments. Intermediate filament proteins. Assembly, organization and movement of cilia and flagella (schematic representation).
Cell wall and extracellular matrix
Prokaryotic and eukaryotic cell wall, cell matrix proteins (concept & examples). Adherence junctions, tight junctions, gap junctions, desmosomes, hemidesmosomes, focal adhesions and plasmodesmata. (Schematically and briefly)
Protein transport
Selective transport of proteins from cytosynthesis to 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 (only mechanism). Protein sorting and export from Golgi. Mechanism of vesicular transport, cargo selection, coat proteins and vesicle budding, vesicle fusion.
Cell cycle, cell death and cell renewal
Eukaryotic cell cycle, restriction point, and checkpoints. Cell division. Apoptosis and necrosis - brief outline. Brief outline of FACS.
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.**

Core P7 – Cell Biology Lab

Cell Biology	
	2 Credits
List of Practical	
1. **Visualization of animal (Squamous epithelium) and plant (Onion) cells by methylene blue.** 2. **Micrographs of different cell components and study of mitosis and meiosis from permanent slides (dry lab).** 3. **Molecular weight determination of protein by SDS-PAGE/Native gel electrophoresis.** 4. **Western blot using College kit from HIMEDA or any other suitable company**	

SEC T1 – Techniques in Biochemistry

Tools and 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**	

a. **Determination of the absorption maxima and molar extinction coefficient (of a relevant organic molecule)**
b. **Determination of concentration of a protein solution by Lowry/BCA method.**
c. **ELISA**

Introduction and importance of virtual labs in biochemistry: Video from Youtube

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.**

Generic Elective-3

CORE COURSE ZOOLOGY III
PHYSIOLOGY AND BIOCHEMISTRY

THEORY (CREDITS 4)

Unit 1: Nerve and muscle 8
Structure of a neuron, resting membrane potential, Graded potential, Origin of Action potential and its propagation in myelinated and non-myelinated nerve fibres, Ultra-structure of skeletal muscle, Molecular and chemical basis of muscle contraction

Unit 2: Digestion 5
Physiology of digestion in the alimentary canal; Absorption of carbohydrates, proteins, lipids

Unit 3: Respiration 5
Pulmonary ventilation, Respiratory volumes and capacities, Transport of Oxygen and carbon dioxide in blood

Unit 4: Excretion 5
Structure of nephron, Mechanism of Urine formation, Counter-current Mechanism

Unit 5: Cardiovascular system 6
Composition of blood, Hemostasis, Structure of Heart, Origin and conduction of the cardiac impulse, Cardiac cycle

Unit 6: Reproduction and Endocrine Glands 7
Physiology of male reproduction: hormonal control of spermatogenesis; Physiology of female reproduction: hormonal control of menstrual cycle Structure and function of pituitary, thyroid, Parathyroid, pancreas and adrenal

Unit 7: Carbohydrate Metabolism 8
Glycolysis, Krebs Cycle, Pentose phosphate pathway, Gluconeogenesis, Glycogen metabolism, Review of electron transport chain

Unit 8: Lipid Metabolism 5
Biosynthesis and β oxidation of palmitic acid

Unit 9: Protein metabolism 5
Transamination, Deamination and Urea Cycle

Unit 10: Enzymes 6
Introduction, Mechanism of action, Enzyme Kinetics, Inhibition and Regulation

PHYSIOLOGY AND BIOCHEMISTRY

PRACTICAL **(CREDITS 2)**

1. Preparation of hemin and hemochromogen crystals

2. Study of permanent histological sections of mammalian pituitary, thyroid, pancreas, adrenal gland

3. Study of permanent slides of spinal cord, duodenum, liver, lung, kidney, bone, cartilage

4. Qualitative tests to identify functional groups of carbohydrates in given solutions (Glucose, Fructose, Sucrose, Lactose)

5. Estimation of total protein in given solutions by Lowry's method.

6. Study of activity of salivary amylase under optimum conditions

SUGGESTED READINGS:

- **Tortora, G.J. and Derrickson, B.H. (2009). Principles of Anatomy and Physiology, XII Edition, John Wiley & Sons, Inc.**
- **Widmaier, E.P., Raff, H. and Strang, K.T. (2008) Vander's Human Physiology, XI Edition., McGraw Hill**
- **Guyton, A.C. and Hall, J.E. (2011). Textbook of Medical Physiology, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company**
- **Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman and Co.**
- **Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). Principles of Biochemistry. IV Edition. W.H. Freeman and Co.**
- **Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009). Harper's Illustrated Biochemistry. XXVIII Edition. Lange Medical Books/Mc Graw3Hill.**

Core T8–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. RBC membrane architecture. (diagram only) **Lateral, transverse and rotational motion of lipids and proteins. Techniques used to study membrane dynamics – FRAP (Example with experiments). Transition studies of lipid bilayer, transition temperature. Membrane fluidity, factors affecting membrane fluidity.**	
Membrane 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. 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. Endocytosis, phagocytosis. Receptor mediated endocytosis of transferrin, envelope virus-host cell interaction	
Introduction to bioenergetics	

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**

Membrane Biology and Bioenergetics Lab	
	2 Credit
List of Practical	
1. **Determination of CMC of detergents.** 2. **RBC ghost cell preparation.**	

3. **Separation of photosynthetic pigment by TLC/ silica gel column.**
4. **Determination of phosphate from crude phospholipid (Lecithin/Cephalin)**

Core T9 – Metabolism of Amino Acids and Nucleotides

Metabolism of Amino Acids and Nucleotides	
	4 Credits
Overview of amino acid metabolism	
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. Disorders of amino acids metabolism, phenylketonuria, alkaptonuria.	
Biosynthesis of amino acids	
Overview of amino acid synthesis. Biosynthesis of non-essential amino acids and its regulation.	
Precursor functions of amino acids	
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	

Precursor 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. DHFR, Metabolism of one carbon units.
Integration of metabolism
Integration of metabolic pathways (carbohydrate, lipid and amino acid metabolic pathways).
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.**
- **Text Book of Molecular Biology by Sivarama Sastri, G Padmanavan and C. Subramanyam**
- **Harper's Biochemistry-details**
- **Lubert Stryer's Biochemistry-details**

Core P9 – 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.**	

Core T10-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 Archaebacteria (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 - 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.

References:

1. Stanier, RY., et al., General Microbiology, 5th ed. Macmillan Press.

2. Pelczar. M., et al., Microbiology, 5th ed.,2000, Tata-McGraw Hill

3. Atlas, RM., Principles of Microbiology, 2nd ed.,1997, McGraw-Hill

4. Salle, AJ., Fundamental Principles of Bacteriology, 7th ed.,1999, Tata- McGraw Hill

5. Prescott, LM., Microbiology, 6th ed. 2005, McGraw-Hill.

Core P10-Basic microbiology and microbial genetics:

Basic Microbiology lab	
	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.**	

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

a. **Collection of blood and storage.**
b. **Separation and storage of serum.**
c. **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., ElsevierMosby 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
- Hawk's book

Generic Elective-4

CORE COURSE ZOOLOGY IV
GENETICS AND EVOLUTIONARY BIOLOGY

THEORY **(CREDITS 4)**

Unit 1: Introduction to Genetics **3**

Mendel's work on transmission of traits, Genetic Variation, Molecular basis of Genetic Information

Unit 2: Mendelian Genetics and its Extension **8**

Principles of Inheritance, Chromosome theory of inheritance, Incomplete dominance and codominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, sex linked inheritance, extra-chromosomal inheritance

Unit 3: Linkage, Crossing Over and Chromosomal Mapping **9**

Linkage and crossing over, Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and coincidence, Somatic cell genetics – an alternative approach to gene mapping

Unit 4: Mutations **7**

Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy; Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations,

Unit 5: Sex Determination **4**

Chromosomal mechanisms, dosage compensation

Unit 6: History of Life **2**

Major Events in History of Life

Unit 7: Introduction to Evolutionary Theories **5**

Lamarckism, Darwinism, Neo-Darwinism

Unit 8: Direct Evidences of Evolution **5**

Types of fossils, Incompleteness of fossil record, Dating of fossils, Phylogeny of horse

Unit 9: Processes of Evolutionary Change **9**

Organic variations; Isolating Mechanisms; Natural selection (Example: Industrial melanism); Types of natural selection (Directional, Stabilizing, Disruptive), Artificial selection

Unit 10: Species Concept **6**

Biological species concept (Advantages and Limitations); Modes of speciation (Allopatric, Sympatric)

Unit 11: Macro-evolution **5**

Macro-evolutionary Principles (example: Darwin's Finches)

Unit 12: Extinction **6**

Mass extinction (Causes, Names of five major extinctions, K-T extinction in detail), Role of extinction in evolution

GENETICS AND EVOLUTIONARY BIOLOGY

PRACTICAL **(CREDITS 2)**

1. Study of Mendelian Inheritance and gene interactions (Non Mendelian Inheritance) using suitable examples. Verify the results using Chi-square test.

2. Study of Linkage, recombination, gene mapping using the data.

3. Study of Human Karyotypes (normal and abnormal).

4. Study of fossil evidences from plaster cast models and pictures

5. Study of homology and analogy from suitable specimens/pictures

6. Charts: a) Phylogeny of horse with diagrams/ cut outs of limbs and teeth of horse ancestors b) Darwin's Finches with diagrams/ cut outs of beaks of different species

7. Visit to Natural History Museum and submission of report

SUGGESTED READINGS

- Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. VIII Edition. Wiley India.
- Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cummings. Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
- Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis. IX Edition. W. H. Freeman and Co.
- Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
- Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring, Harbour Laboratory Press.
- Hall, B. K. and Hallgrimsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
- Campbell, N. A. and Reece J. B. (2011). Biology. IX Edition, Pearson, Benjamin, Cummings.
- Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.

Core T11 – Chromosome Organization, Replication and Repair

Chromosome 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.
Transposition of DNA
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, trans versions, 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.
- Text Book of Molecular Biology by Padmanavan

Core P11 – Gene Organization, Replication and Repair Lab

Gene Organization, Replication and Repair	
	2 Credits
List of Practical	
1. Determination of the melting temperature and GC content of DNA. 2. Study of viscosity of DNA solutions (bacterial genomic DNA, plasmid DNA and DNA from different sp.[Calf thymus]). 3. Agarose gel electrophoresis and estimation of DNA size by using markers.	

Core T12 – 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, induction of SOS response.

Mendel's principles & chromosomal basis of heredity and Extensions of Mendelism

Genetics:

Basic principles of Mendelian genetics (monohybrid and dihybrid, test and back crosses); Bacterial genetics-transformation, transduction, conjugation (mention of F^+/F^-, Hfr strain, function of pillus)

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**
- **Text Book of Molecular Biology by Sivarama Sastri, G Padmanavan and C. Subramanyam**
- **Stryer's Biochemistry**
- **DNA Structure and Function Richard R. Sinden- provide details for these 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.

Core P12 – Gene Expression and Regulation Lab

Gene Expression and Regulation	
	2 Credits
List of Practical	

1. **Extraction of total nucleic acids (genomic DNA) from bacterial cells and quantitative estimation of DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A260 measurement).**
2. **Concept of standard curve and estimation of unknown DNA concentration using calf thymus DNA.**
3. **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).**
4. **Induction of lac operon and enzyme assay (beta-galactociadase assay).**

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. 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.
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

BMI, 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 Nutriceuticals

Alcohol, chewing tobacco 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 Strings, S.E, Raymond, J. 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.
- Debojyoti Das's Biochemistry Book- provide details

DSE P1- Nutritional Biochemistry Lab

Nutritional Biochemistry	
	2 Credits
List of Practical	

1. Estimation of Vit-C from fruit juice.
2. Estimation of calcium from milk.
3. Estimation of total phenolic content from black-Tea.
4. Determination of iodine number from vegetable oil.
5. Estimation of phosphorous from milk.

DSE T2 –Infectious and Non-Infectious Diseases

Infectious and Non-Infectious Diseases	
	(4+1) Credits
Classification of infectious agents (brief introduction)	

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 (brief introduction)
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 (examples only)
The factors and biochemistry underlying Diabetes and related complications: the influence of genetics and environment on the condition and management
Cancer (brief introduction)
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; Adeno carcinoma, Biochemical analysis of cancer (PSA, AFB protein marker).
Other diseases (brief introduction)
Introduction to protein folding and proteosome removal of misfolded proteins; etiology and molecular basis for Alzheimer's, Prion diseases (mad cow), Huntington's Chorea, sickle cell anemia, Thalassemia, Parkinson's.
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.
- Gyton's medical physiology

Infectious and Non-Infectious Diseases Lab

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 by kit method.**
4. **Permanent slides (histology and cytology) for different types of cancer**

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.
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 Technology by Watson**

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.**	

Core T14 – Immunology

Immunology	
	4 Credits
Cells and organs of the immune system	
Hematopoiesis, cells of the immune system, primary andsecondary 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.

Core P14 – Immunology Lab

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

DSE T3– 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, 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. Various types of biomolecular interactions: protein-ligand, protein-protein, DNA-protein. (simple technique with example) Inhibition of interactions. Application of molecular interaction analysis in life science research, drug discovery and diagnostics
Reference Books
▸ **Lehninger's Biochemistry** ▸ **Lubert Stryer** ▸ **Book on Biomolecular Interactions**

DSE P3 – Advanced Biochemistry Lab

Advanced Biochemistry Lab	
	2 Credits
List of Practical	
1. Separation of photosynthetic pigments by TLC/silica gel column. 2. Spectrophotometric quantitation of protein (Lowry) and preparation of standard curve. 3. Absorption spectrum of haemoglobin and determination of concentration and extinction coefficient.	

DSE T4 -Molecular Diagnostics

Molecular Diagnostics	
	4 Credits
Introduction To Biochemical Diagnostics	
Inborn errors of metabolism.	
Diagnostic Enzymes	
Principles of diagnostic enzymology; Clinical significance of aspartateaminotransferase, alanine aminotransferase, creatine kinase, aldolase, lactatedehydrogenase, enzyme tests in determination of myocardial infarction, enzymes ofpancreatic origin and billiary tract.	
Immunodiagnostics	
Introduction, antigen-antibody binding and assays; Immunoassays –types [RIA,ELISA, Chemiluminescent IA, FIA] and specific applications; Immunohistochemistry-principle and techniques. Immunodiagnostics 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. Application of genetic test. Karyotyping, chromosome banding and fluorescence In-situ hybridization techniques. **Disease identification and Genetic tests for following disorders: Thalassemia, Sickle Cell anemia, Down Syndrome, Sex-linked inherited disorders, Allelic susceptibility test for multifactorial disorders (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 by Watson
- Experimental Biochemistry: A Student Companion
- Harper's Biochemistry

DSE P4– Molecular Diagnostics Lab

Molecular Diagnostics	
	2 Credits
List of Practical	

1. **Estimation of Surface antigen of Hepatitis B & Hepatitis C virus.**
2. **Lipid profile: triglycerides and total cholesterol.**
3. **Permanent slides (histology/cytology) for different types of cancer and comparison with slides from normal tissues**
4. **Permanent slides of pathogens: Plasmodium vivax and P. falciparum**
5. **Estimation of serum Alkaline phosphatase and Acid phosphatase.**